POWER PLANT ENGINEERING

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Generating Power With Exhaust from Mill Engines

MIXED PRESSURE TURBINES AND REGENERATORS IN PLANT OF NATIONAL ENAMELING & STAMPING CO. MAKE POSSIBLE THE UTILIZATION OF STEAM FORMERLY WASTED

AMONG THE GREATEST problems of today is the elimination of waste in whatever form it may take place and many industrial processes are carried out in such a manner that great losses occur unless provision can be made to utilize the discarded energy or material as a by-product. In steel mills, for example, reversing mill engines are inherently extravagant in the use of steam and it was to make use of the exhaust from such engines for power purposes that the new power plant was built at the steel works of the National Enameling & Stamping Co. at Granite City, Ill. With such an arrangement, the principal feature is the regenerator for the storage of steam between the engines and the low-pressure turbine. The function of the regenerator is analogous to the flywheel in that heat from the exhaust steam is absorbed by water during times when the supply is greater than the demand and is given up to make steam for the mixed pressure turbine when the supply is less than the demand.

Previous to the time this plant was put into operation, the mills were supplied with 250 v. direct current from a Corliss engine driven unit, but depended upon an outside power plant for alternating current while the exhaust from the mill engines was going to waste. An engineering survey of the conditions surrounding the plant indicated, however, that by the installation of mixed pressure turbines all the needs of the mills for electric power could be supplied by the use of the ex-

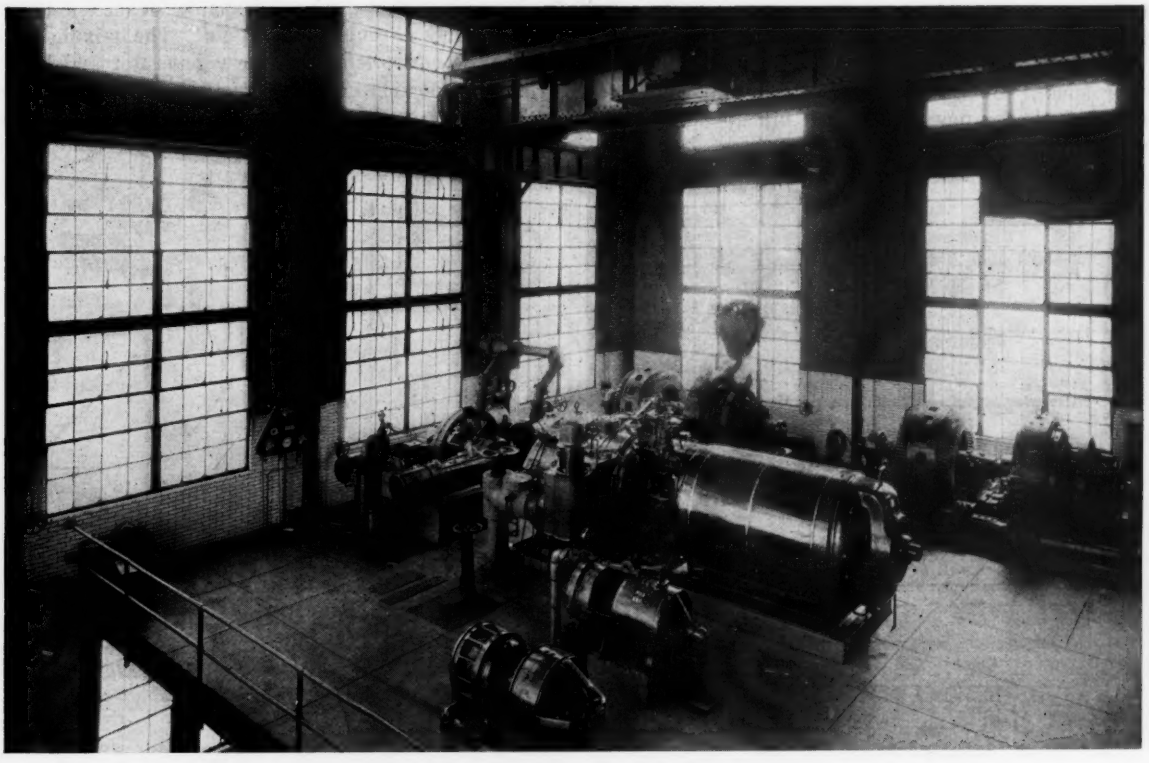


FIG. 1. GENERAL VIEW OF TURBINE ROOM BEFORE INSTALLATION OF SECOND UNIT

haust from the mill engines except during periods when the engines were stopped for several minutes. During these periods, high-pressure steam directly from the boilers is delivered to the turbines, the transfer being automatic and only in proportion to the needs.

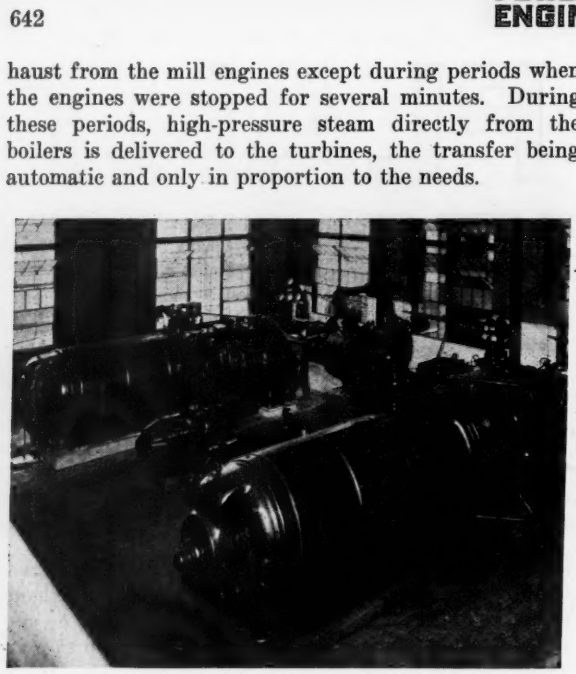


FIG. 1A. MIXED PRESSURE GENERATING UNITS

The source of the exhaust steam is from three 36 by 48-in. twin engines operating universal mills designated as Nos. 1 and 2 and plate mill No. 1 and from the hydraulic pumps. In addition to these sources, provision is made to use the exhaust from the auxiliaries in the power house. Exhaust steam from the mill engines is conducted to the power house by underground steam lines consisting of 16 and 20-in. wrought iron pipes insulated with 5-in. sectional wood covering. At each engine a receiver is provided which has a volume equal to 68 times the volume of the engine cylinder and is provided with an atmospheric relief valve set to discharge at about 4 lb. pressure.

When exhaust steam is not sufficient to supply the needs of the turbines, high-pressure steam in sufficient quantity is used which comes direct from the main boiler plant through a 10-in. overhead line installed on steel supports. This line is 220 ft. long and being exposed to the weather is insulated with 1½-in. Nonpareil high pressure pipe covering finished with a ½-in. coat of high pressure cement and waterproof jacket.

At the power plant end of this transmission line, a steam separator with receiver and trap keeps the line free of condensate at all times so that whenever steam is needed by the turbines no water will be delivered to them.

The low-pressure steam is delivered from the underground lines into two regenerators located just outside the turbine plant. These are 9 ft. in diameter and 50 ft. long, but are not now insulated, as the supply of exhaust at present is in excess of requirements. The capacity of these regenerators is such as to supply the needs of the turbines running fully loaded for 2 min. after the mill engines have been entirely shut down.

In Fig. 6 are shown sectional views of a regenerator to illustrate its operation. Exhaust steam enters two mixing tubes through a manifold. The mixing tubes extend the entire length of the regenerator and have a cylindrical portion in the steam space of the regenerator with a contracted part extending down into the water. The walls of this narrow portion are perforated with

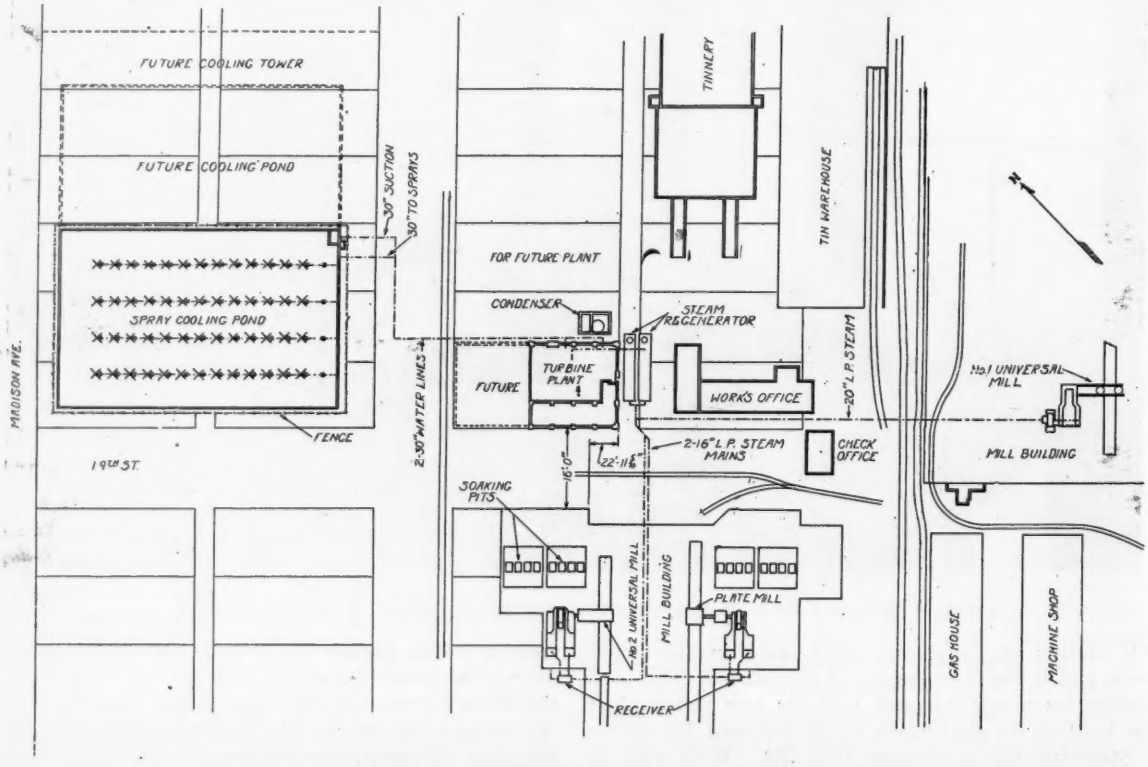


FIG. 2. PLAN OF WORKS SHOWING SOURCES OF EXHAUST STEAM

numerous small holes which discharge the steam into the water and raise its temperature to that of saturated steam at the existing pressure. The upward motion of the steam keeps the regenerator water in circulation around the baffles and assures a practically uniform temperature of the water. When steam ceases to flow into the regenerator, circulation is still maintained as the rising columns of water liberate steam and thus remain lighter in weight than the volume on the other side of the baffle so the water continues to circulate and give off steam at a gradually lowering pressure until exhaust steam is again supplied or the pressure is reduced to the minimum allowable and high-pressure steam is admitted to the turbine.

Steam leaves the regenerator for the turbine through a dome the entrance to which is protected from moisture by a baffle plate, and an automatic water level device which removes the water of condensation entrained with the exhaust steam. From the regenerators the steam is carried to the turbines through a 30-in. header.

automatically to admit high pressure steam in sufficient quantity to carry the load when the low pressure exhaust steam is not sufficient to supply the needs, the turbines may, therefore, be operated on either high or low pressure steam exclusively or as mixed pressure units.

When operated as high-pressure units, they have a guaranteed full load water rate of 16.8 lb. per kw.-hr. with dry steam at the throttle at 150 lb. pressure, and a vacuum of 28 in. This feature of the turbines permits economical operation even when the mill engines are not running.

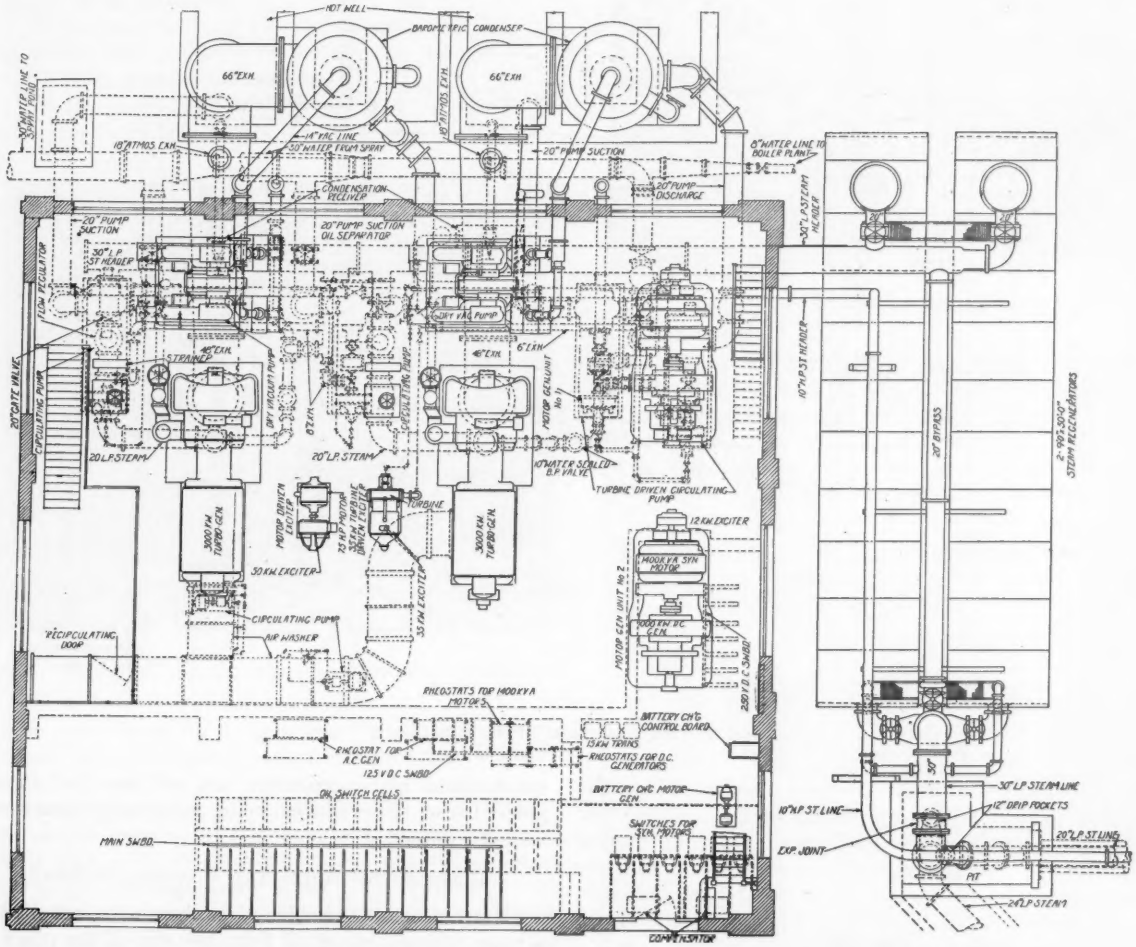


FIG. 3. ASSEMBLED PLAN OF POWER PLANT MACHINERY AND PIPING

Generating Equipment

THE POWER generating equipment consists of two mixed pressure turbine units each rated at 3000 kw., 80 per cent power factor, operating at 3600 r.p.m. The governing mechanism of the turbine is so designed as

Electric energy is generated at 2300 v., a.c., the wiring system employed being 3 phase, 60 cycles. Cooling air for the generator windings is brought to the generator in ducts so arranged that the air may be drawn from outdoors and discharged outdoors if desired, but provided with dampers so that part or all of the air may be taken in from or discharged inside the plant for heating purposes during the winter months. An air washer is also provided for conditioning the air before it passes through the generator.

For each generating unit, a cast-iron barometric condenser is provided, located just inside the building wall and connected to the turbines by 66-in. exhaust pipes. As the turbines have a total steam consumption

when running on exhaust steam of about 72,000 lb. per hr. each, however, the condensers are each designed for a maximum rating of 90,000 lb. per hr.

Auxiliary condensing equipment for each condenser consists of one 10 by 27 by 14-in. vacuum pump and two centrifugal pumps, driven by steam turbine through reducing gears. One of these handles the water from the basin of the cooling pond to the condenser and the other from the condenser hot well through the spray cooling equipment. This cooling system consists of a concrete basin which serves also as a reserve storage reservoir, over which is located a series of spray nozzles which have a total capacity of 20,000 g.p.m.

Field excitation for the main units is furnished by a 50-kw. induction motor driven set exciter with a 35-kw. steam turbine driven unit as a reserve.

Throughout the mill, with the exception of one plant which was but recently started up, the electrical system used is 250-v. d.c. and to supply this system two 1000-kw. synchronous motor-generator sets are installed in the power house, the excitation being supplied by direct connected exciters.

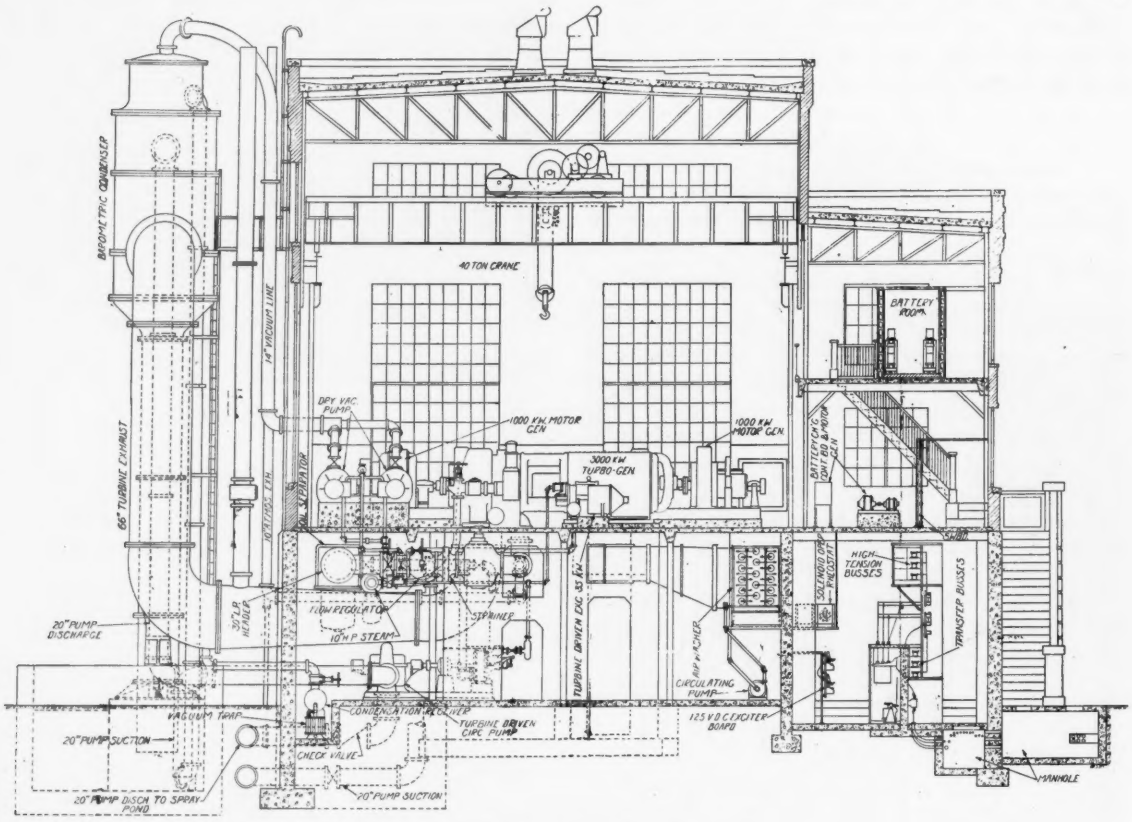


FIG. 4. CROSS SECTION OF POWER PLANT

Electric Switches and Control Systems

High tension switchboard equipment is installed in a room entirely closed off from the rest of the plant on

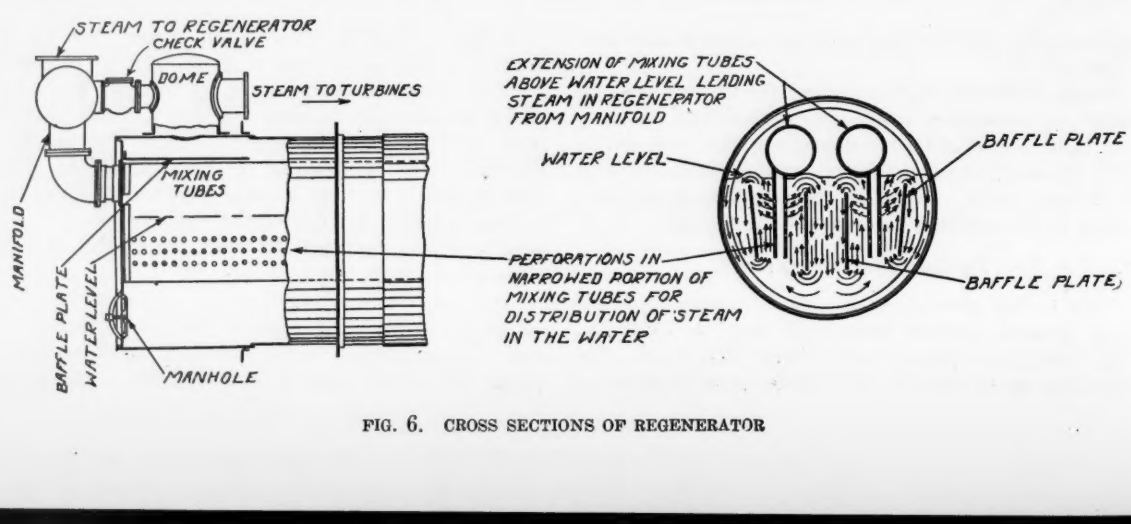


FIG. 6. CROSS SECTIONS OF REGENERATOR

the ground floor. Generator and circuit oil switches are solenoid operated and mounted in individual cells. The high tension busses and disconnecting switches are mounted on pipe framework over the cell structure and provided with necessary barriers. The bus layout provides for a ring bus with sectionalizing switches, disconnects, etc.

To provide for inspection and repairs of oil switches while the plant is in operation, a spare oil switch and transfer bus has been installed which may be used in place of any other oil switch by the proper handling of double throw disconnects. The control and overload protector for any circuit may be transferred to the spare switch by means of a double throw knife switch on the main panel board.

Compensators and solenoid operated oil switches for operating the synchronous motors are located at the end of the main cell structure.

In the same room with the high tension switching equipment are the switches for the control of excitation.

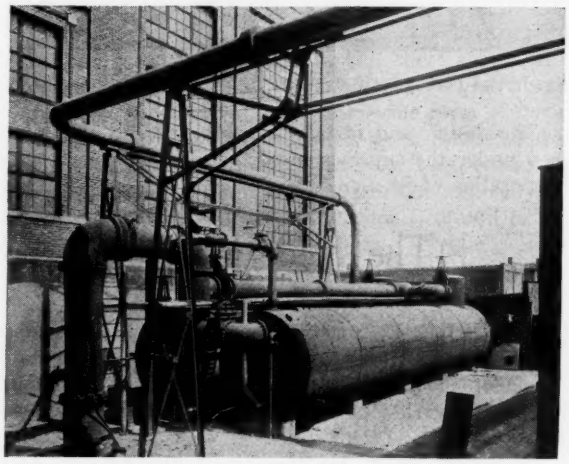


FIG. 5. REGENERATORS LOCATED JUST OUTSIDE POWER PLANT

These are located on a slate panel board and are all solenoid operated remote control carbon break switches, controlled from the main board.

The exciter bus is in two sections with a tie between. One section handles the two main exciters and turbogenerator field, and the other the direct connected exciters on the synchronous motor fields. One automatic regulator has been provided for operation in connection with the main exciters for voltage regulation on the main unit, and another for power factor correction on the synchronous motors. All exciter and generator field rheostats are solenoid operated and are mounted above the exciter board.

Switches for the control of the 1000-kw. d.c. generators and the outgoing 250-v. circuits are located on a separate panel board in the main switch room on the ground floor. The generators have solenoid operated carbon breakers on the positive and knife switches on the negatives and equalizers. The outgoing circuits are also equipped with solenoid breakers on the positives and knife switches on the negatives.

The main operating board consists of 12 slate panels located on the main turbine room floor. It is equipped with a full complement of indicating and integrating instruments which will enable the operator to keep a complete log of operations. The watthour meters are mounted on the rear of panels.

Necessary controls for oil switches, field switches, rheostats, etc., are conveniently arranged and a "mimic

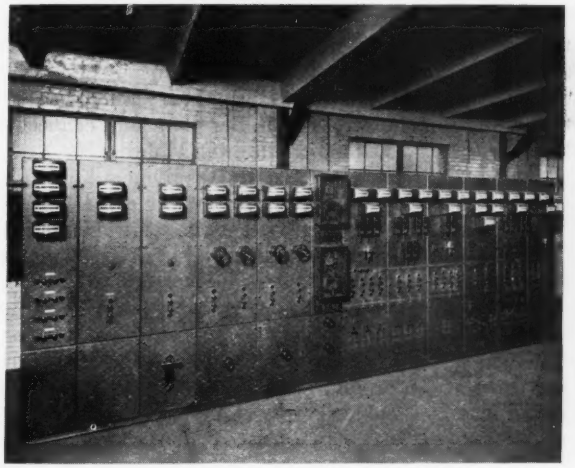


FIG. 7. VIEW OF MAIN SWITCHBOARD

bus" is provided across the entire board by means of which the operator may at all times have before him an indication of the position of all oil switches and disconnects.

Current for operating solenoids is provided, normally, by a small motor-generator set located on the

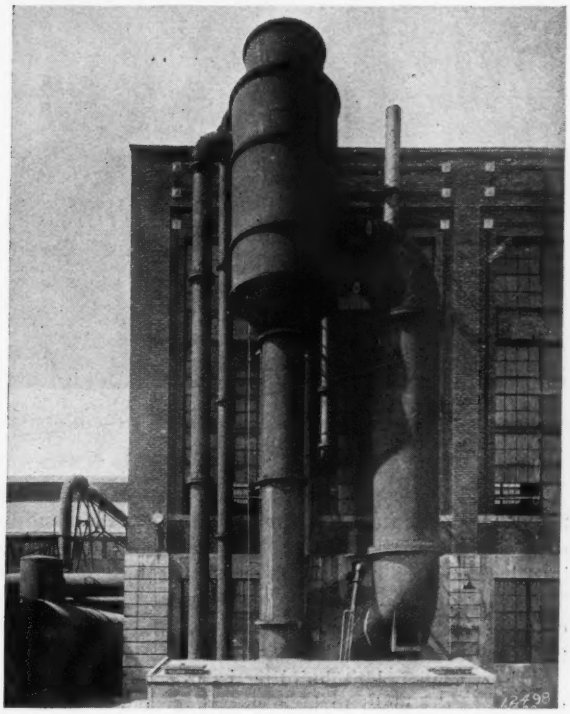


FIG. 8. BAROMETRIC CONDENSER SERVING FIRST UNIT INSTALLED

turbine room floor, and a storage battery installed on the gallery over the operating board. Switches are provided so that the control may be thrown on to the exciter bus if desired.

At the present time, the lime burning plant and a 2000-hp. motor driven bar mill are the only parts of the works that are run on alternating current, and the a.c. feeders to these consist of three conductors, varnished cambric insulated, lead covered cable installed in fiber conduits. The cable to the line plant is brought out of the ground some distance from the plant and connected to an overhead line running into the building.

All the switching and control equipment for additional a.c. circuits have been provided, and feeders will be installed as required. In order to eliminate the danger from overhead distribution, it is proposed to install all high tension feeders underground.

A 40-ton crane is installed to serve the main units and provisions have been made on the operating floor for the handling of heavy equipment into and from the plant at the ground level. This crane was built up in the National Enameling & Stamping Co.'s shop from parts of two cranes which had been outgrown and discarded. The bridge was formerly used as a ladle crane, but due to a change in furnace capacity, was replaced by a crane with heavier construction. This bridge was cut off to the proper length and some slight changes made to render it suitable for use in the new power house. The trolley was built up from parts of an old stripping crane which was no longer in service.

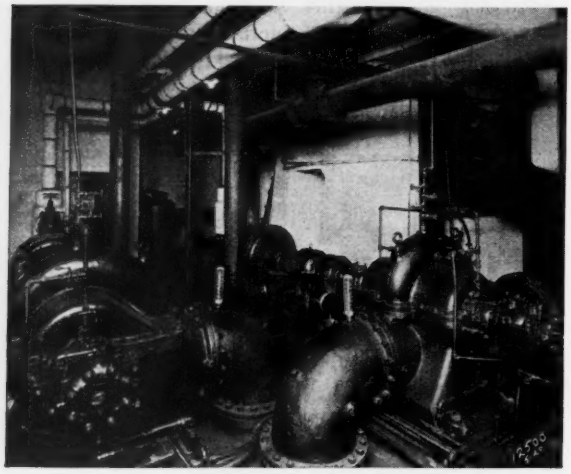


FIG. 9. PUMPS FOR CIRCULATING WATER IN CONDENSER AND COOLING POND

The old power plant contains a Corliss engine driven 250-v. d.c. generator which has been used as a stand-by since the installation of the first turbo-generator, a tie line between the two plants was therefore necessary. This was installed entirely underground and consists of varnished cambric insulated lead covered cables in fiber conduit.

The turbine plant building is of concrete construction up to the main turbine operating floor with superstructure of steel framework and brick curtain walls. The windows are equipped with steel sashes glazed with wire glass. The roof is of hollow reinforced cement tile with 4 in. of cinders on top with a regulation waterproof roof covering. This construction was adopted in order to guard against trouble from condensation. Space is provided at the end of the plant for extension of the building should additional units be required.

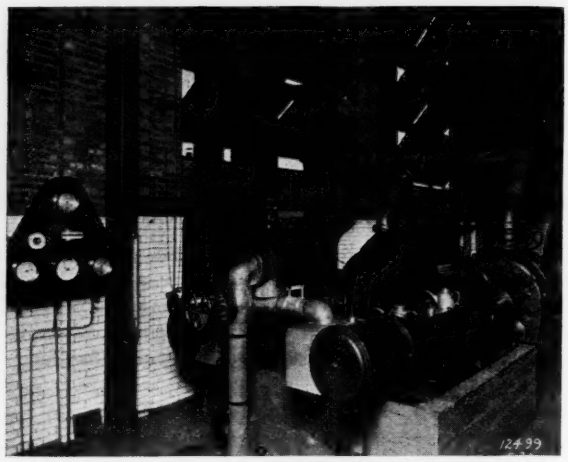


FIG. 10. VACUUM PUMP SERVING CONDENSER

The design and installation work of this plant has been under the supervision of the Engineering Service Corporation of St. Louis.

The Trade Journal

By J. B. Dillon

SOMEWHERE, sometime, someone said: "It takes all kinds of people to make a world." If the statement had been: "It takes all kinds of tradesmen to make a world," I would feel more like adding my Amen.

Practically all of the prominent, active trades have a trade journal catering exclusively to the needs of those engaged in the various lines of business. In the columns of these journals are published timely articles written by workers in the field. Few, if any, of these articles tell of wild theories, but generally abound with suggestions for the better way of doing things.

I have often heard it remarked: "Oh, I read a similar article to that 10 yr. ago, why don't they print something new?" The facts are that there is much new matter in practically every issue of a trade paper, but there are some readers who mistake new ideas for old ones. Real progress is generally the result of evolution. Many of the old ideas have required a deal of furbishing over a long period of time before they became of practical value, and it is the little forward steps that are made as time goes on that mark improvement and progress. What you may have seen 10 yr. ago as a new idea may have resembled what you saw described in a late issue of a trade paper, but the later reference in reality shows what some thinker and plodder has done with the original idea.

If all of the various trades were to call for something new and original every day, there would be no experts in any line. It is only by doing the same thing over and over that we become expert.

We often review, rehash, repeat and ponder if we wish to retain certain nuggets of wisdom.

Auxiliary Equipment for Elevated Water Tanks---I

KINKS ON THE INSTALLATION OF LIQUID LEVEL INDICATORS AND PUMP CONTROLS. BY CHARLES L. HUBBARD

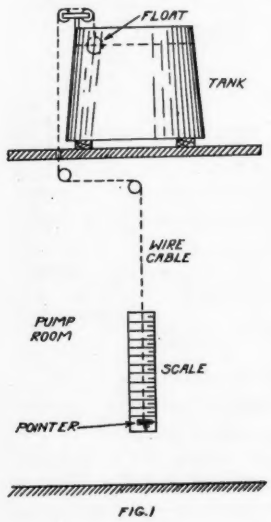
ELEVATED tanks used for the water supply of industrial plants and as a part of the sprinkler system for large buildings of all kinds, are usually erected complete by the manufacturers or their representatives.

Certain auxiliary equipment, such as pump and overflow connections, water-level indicators, automatic pump control and construction to prevent freezing, are details which often come under the direction of the operating engineer.

Devices manufactured especially for these various purposes and also homemade equipment which often answers the purpose just as well and is much less expensive to install, are described here.

WATER LEVEL INDICATORS

UNLESS the tank is furnished with some reliable automatic means for keeping it full there should be a convenient indicator for showing the height of the water level at all times, or at least some form of device for indicating high and low water, as an electric bell or a small whistle, operated by steam or compressed air. Even when the pump is operated automatically by changes in the water level in the tank, it is well to provide a high and low level telltale of some form in case of accident to the automatic equipment. When the tank is in full view of the pump or engine room, a numbered gage board on the outside, with a metal indicator operated by float, is often all that is necessary.



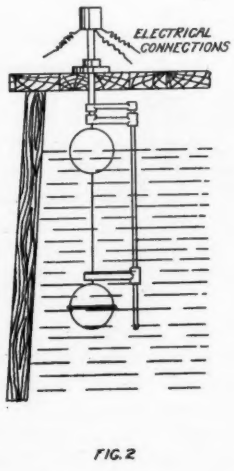


FIG. 1. MECHANICAL DISTANCE TYPE LEVEL INDICATOR
FIG. 2. ELECTRIC CONTACT HIGH AND LOW LEVEL ALARM

When the tank is above the pump room, and therefore out of sight, it is often possible to bring down a small wire cable through tubing or over pulleys and attach it to an indicator located near the pump as shown in Fig. 1. If this is not convenient, or the tank is at some distance, a number of different forms of electric indicators are frequently used. Figure 2 shows a type for both high and low water which may be purchased ready for attaching either to an open or closed tank. At the upper and lower positions the floats operate a sliding rod which makes the proper electrical contact in the small weather-proof casing at the top, from which wires are carried to bells in the engine room, these bells are pitched differently to indicate high and low water.

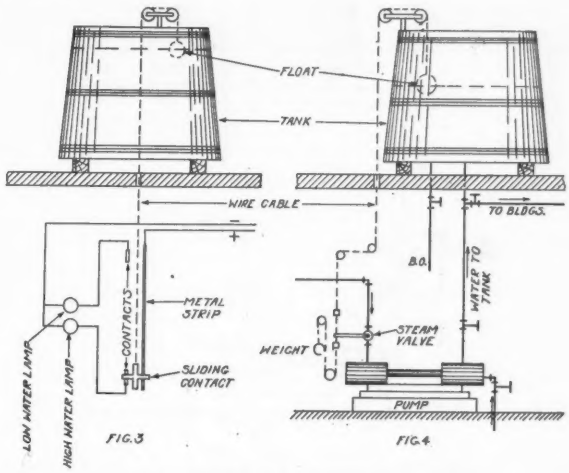


FIG. 3. EXTERIOR ELECTRICAL ALARM
FIG. 4. FLOAT CONTROLLED PUMP THROTTLE

Another arrangement which may be constructed by any mechanic is illustrated in Fig. 3. In this case, a sliding counter-weight attached to a float makes electric connection when the latter is at the high and low water positions. This gives its signals by turning on red and green lights. Sometimes this scheme is arranged for electric contact at 12-in. intervals down the side of the tank, and intermediate white lights between the red and green ones indicate the water level at any time, within one foot.

A comparatively simple arrangement for indicating the exact quantity of water in the tank at all times is a mercury gage which may either be purchased ready for installation or made up from standard fittings. This gage may be located at any convenient point; it is necessary only to connect the mercury column to the tank by means of a small pipe, or it may be connected with any existing pipe leading directly to the tank in which the velocity of the water is not sufficient to affect the pressure.

Altitude gages, similar in construction to a steam gage, may also be used for this purpose, in place of the mercury column. These ordinarily indicate the height of the water level above the gage, but may be provided with a special dial calibrated to show the height of water in the tank.

AUTOMATIC STARTING AND STOPPING DEVICES

ONE OF THE simplest methods of controlling the water level in a tank fed by city pressure is by means of

an ordinary ball-cock or float valve. If the tank is supplied by means of a direct-acting steam pump, and is located approximately above it, the arrangement shown in Fig. 4 may often be employed to advantage. This consists of a small wire cable, attached to a float at the upper end and a weight at the lower end to which stops are attached at proper points to open and close the pump

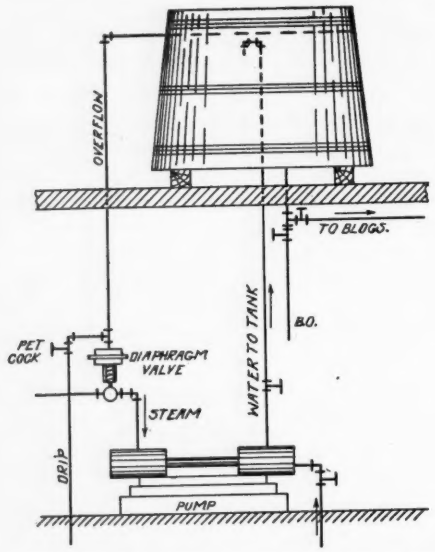


FIG. 5. OVERFLOW PRESSURE CONTROLLED PUMP THROTTLE

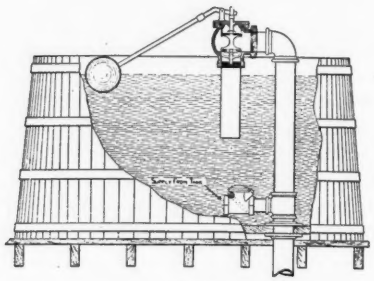
throttle to maintain the water level within the desired limits. This system may be subject to various modifications for meeting other conditions than those shown in Fig. 4.

In the arrangement illustrated in Fig. 5 a special regulator adaptable to any case where an overflow connection may be made, without danger of freezing, is used to operate the pump throttle. The regulator consists of a balanced valve, the stem of which connects with a diaphragm which is connected by a small pipe line to the tank at the overflow level.

The pump continues in action until the tank is filled to this point, when water overflows into the diaphragm chamber. When a column has accumulated in the pipe of sufficient height to overcome the upward force of the spring, the steam valve is closed and the pump stops, and will not start again until the water in the overflow pipe is discharged through a small drip cock which is left partially open. The level to which the water is allowed to fall before the pump starts again is regulated by the drip cock, as the wider it is opened the sooner the water will be discharged and the pump started.

Another type of automatic pump regulator is illustrated in Figs. 6 and 7. Referring to the first of these: When the water level reaches the maximum for which the device is set the float closes the valve at the end of the discharge pipe, and so immediately raises the pressure within it. This rise in pressure is communicated from the discharge chamber of the pump through a small pipe to a diaphragm valve in the steam pipe, Fig. 7, thus shutting off the pressure and stopping the pump. Water for distribution to the plant enters the main riser through a check valve opening inward as shown in Fig. 6. When the level in the tank has been lowered sufficiently to open the float valve, the pressure in the discharge pipe falls and the excess pressure is released from the diaphragm valve, thus allowing it to open and again admit steam to the pump.

A controlling device adapted either to steam or electrically driven pumps is shown in Fig. 8. A small pipe from the tank is connected to a diaphragm chamber at the point shown, and when the height of the column becomes sufficient to raise the diaphragm slightly, the movement is communicated through a weighted lever to a pilot valve, which, in turn, admits water pressure behind the working piston which operates the steam valve or electric switch. A reverse movement, due to a fall in pressure, produces a piston stroke in the opposite direction. This device may be equipped with a variating attachment for permitting any predetermined variation of pressure between the starting and stopping of the pump. Another form is made with a compensating



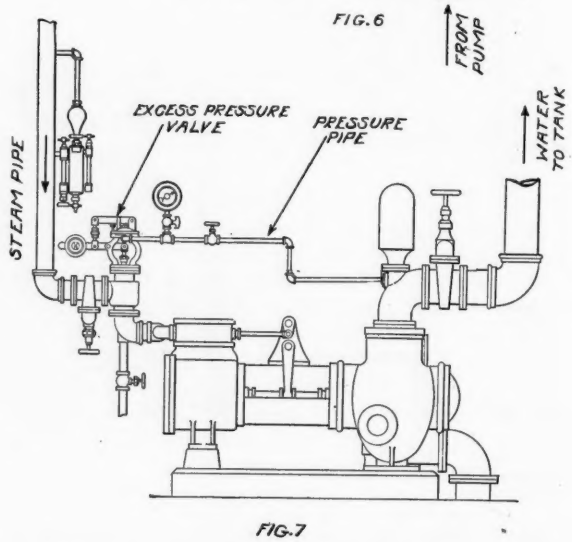


FIG. 6. FLOAT CONTROLLED VALVE AT FILLING PIPE DISCHARGE

FIG. 7. HEAD PRESSURE THROTTLE REGULATOR

attachment for operating rheostats with a step by step movement which is desirable in starting up large or medium sized electrically driven pumps. There are various other devices upon the market both for indicating the height of the water in the tank and for controlling the pumping equipment, but the examples given will serve to illustrate the general principles involved and for suggesting homemade devices along similar lines.

Screens for Suction Pipes

While it is important to know conditions in the tank and to control the water level, it is of equal importance to care for the suction pipe leading to the pump. The method employed for protecting the end of the pipe will depend largely upon the source from which the water is drawn and should be constructed in such a manner as to prevent sticks, leaves and other debris, as well as mud and air from being drawn into the pipe, at all seasons of the year. The sketches shown represent typical methods recommended by the Associated Factory Mutual Fire Insurance Companies, and have been selected with a view of covering three or four of the more usual conditions found in practice.

Figure 9 shows the tank supply as being taken from the penstock leading to the water wheel, in which case a fine screen only will be required, as the coarser material will have been removed at the entrance to the penstock.

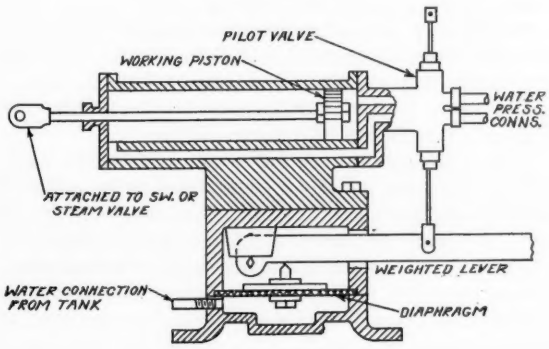


FIG. 8. RELAY HYDRAULIC PRESSURE GOVERNOR

The general form and method of placing this in the suction line is clearly indicated in the sketch. It is easily accessible for cleaning by removing the cap, and is provided with a screw and hand wheel for raising it temporarily in case it should become clogged during a fire or other emergency. The screen should be made of copper wire with ½-in. mesh and have sufficient area to reduce the velocity of flow through it to about 40 ft. per min.

When the water is taken from a rapidly flowing stream cylindrical screens of the form shown in Fig. 10 give good results, as they are, in a measure, self cleaning, and do not ordinarily require attention more than once or twice a year. They should be constructed of brass or copper tubing, No. 10 or 12 gage, drilled with ½-in. holes on ¾-in. centers. The length for different diameters of pipe should be approximately as follows:

Diameter of pipe, in.	Length of screen
3	2 ft. 10 in.
4	3 ft. 10 in.
5	4 ft. 6 in.
6	5 ft. 6 in.
8	6 ft. 0 in.

The cone plug at the end should always point upstream and may be made to serve as a means of support as indicated. The height above the bed of the stream should be such that there will be not less than 6 in. of water over the top of the screen at all seasons of the year. A substantial iron bar or stake driven 2 or 3 ft. in front of the cone serves as a protection against heavy floating material.

A typical arrangement for taking water from a pond, canal, or other source where there is but little if any current, is shown in Fig. 11. The outer rack consists of iron rods or bars about 2 in. apart. The inner screens

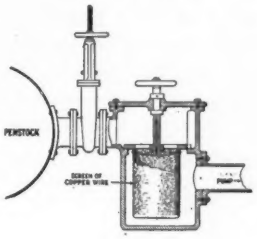


FIG. 9

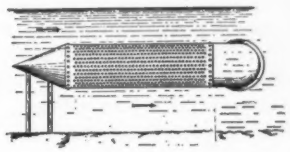


FIG. 10

FIG. 9. PUMP SUCTION SCREEN
FIG. 10. TYPE OF INTAKE FROM SWIFT STREAMS

are of copper wire, ½-in. mesh, with a space of 8 or 10 in. between them. These slide in vertical grooves and are removable for cleaning. In use, only one should be in place at a time, the other being held in reserve. The area of the screen should be at least 1 sq. in. per gallon of water pumped per minute. The top of the suction pipe should enter the intake at such a level that it will be submerged 10 or 12 in. at low water. When shallow water conditions prevail, an elbow may be used, as indicated by the dotted lines, or a plank shelf may be built, extending 18 or 20 in. beyond the end of the pipe. If the depth of the water is so shallow as to require a wider intake than is convenient to construct, it may be made to project into the pond, as shown in Fig. 12.

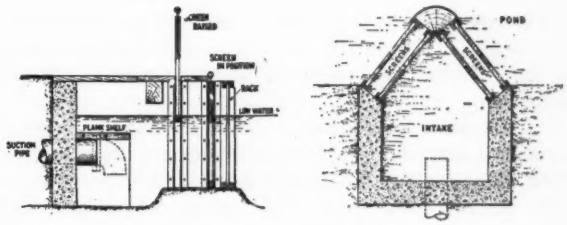


FIG. 11. INTAKE FROM CALM WATER
FIG. 12. SHALLOW POND INTAKE

(Editor's Note: The second part of the author's article on auxiliary equipment for elevated water tanks which will concern itself with a consideration of methods employed to prevent freezing in exposed tanks will appear in an early issue.)

U. S. Public Health Service doctors are studying how to prescribe for streams that are suffering from over contributions of sewage. When once a quantitative relation between the pollution on the one hand and the population industrial wastes, stream flow, and temperature on the other has been established, the stream doctors will be better able to prescribe the sort of tonic that will restore the stream to health and make it available for drinking or industry or both.

Recording Ash-Pit Loss*

RELATION OF ASH-PIT LOSS TO OTHER FACTORS AFFECTING FURNACE EFFICIENCY AND CAPACITY AND PRELIMINARY DATA OBTAINED FROM DEVICE FOR RECORDING ASH-PIT LOSS. BY E. G. BAILEY

THERE has been more guesswork and less knowledge regarding ash-pit loss than any other thing of equal importance in the boiler plant. It pays to watch the ash pile from every kind of stoker or even hand-fired furnaces, though it be only visual inspection to note whether it is well burned out or full of combustible. To sample and analyze the ashes regularly and calculate the heat lost in that manner is better still, yet it is done in comparatively few plants.

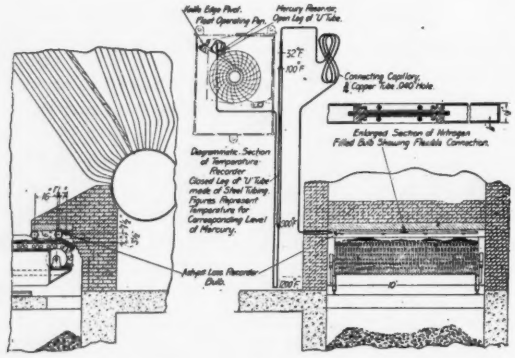

Mercury Reservoir, Open Leg of "U" Tube.
Connecting Capillary & Copper Tube .040 Hole.
Enlarged Section of Nitrogen Filled Bulb Showing Flexible Connection.
Diagrammatic Section of Temperature Recorder Closed Leg of "U" Tube made of Steel Tubing. Figures Represent Temperature for Corresponding Level of Mercury.
Ash-pit Loss Recorder Bulb.

FIG. 1. ASH-PIT LOSS RECORDER INSTALLATION ON NATURAL-DRAFT CHAIN GRATE STOKER

Even the sampling and analysis of the ashes fall far short of accomplishing the desired result. A sample taken from the entire plant each day leaves the responsibility divided between the different firemen and different types of stokers. To take a sample from each boiler for each shift would still not accomplish as good results as if the ash-pit loss were continuously recorded for each boiler.

Instantaneous readings of any kind are most valuable in aiding the fireman to obtain results. He can then see a faulty condition as soon as it takes place or even starts to take place, and remedy it promptly. If such readings are recorded continuously the firemen can see how quickly the remedy is effective. Such records also show the executive in charge of the plant just what took place at all times.

It is the purpose of this paper to present some preliminary data obtained from a device recently developed to record the ash-pit loss from chain-grate stokers. It may later be extended to some other types of stokers of either the present or modified design, but the great need for it on chain grates led to its being applied to these first.

METHOD OF RECORDING ASH-PIT LOSS

THE FUNDAMENTAL principle used in recording the ash-pit loss by this method is to place a temperature-recorder bulb at a point near where the ashes are discharged from the active section of the grate or furnace. The bulb is not in contact with the ashes but receives only the radiant heat from the coke being discharged. The relation between this temperature and the amount of combustible in the refuse, and the heat loss due to it, is established by taking a series of samples corresponding to different temperature readings.

If the ashes are well burned out, so that there are no live coals, the temperature is comparatively low. Even though the ash has clinkered rather badly and retained a certain amount of temperature, it has usually lost its glow and is comparatively cold from a radiation standpoint. The coke coming over is still ignited and at a temperature of about 1800 to 2000 deg. F., so that its radiant heat to the bulb is sufficient to cause very decided changes in the temperature readings.

In selecting a location for the temperature-recorder bulb, it is necessary to have it shielded from any radiant heat of the furnace itself, and also as free as possible from changes in temperature due to the surrounding brickwork, circulation of air, etc.

It is necessary that the bulb extend across the entire width of the grate and be so constructed as to obtain an accurate average in case the amount of coke coming over is greater on one portion of the grate than another.

Figure 1 shows an installation on a natural-draft chain-grate stoker with a 9-ft. bulb located just beyond the waterback, which shields it from the heat of the furnace. It is located about 7 in. above the rear end of the grate, so that the radiant heat from any coke passing under it will increase its temperature.

THE TEMPERATURE RECORDER

THE TEMPERATURE-RECORDER bulb itself is constructed of 1½-in. steel tubing with ⅛-in. wall and all joints are

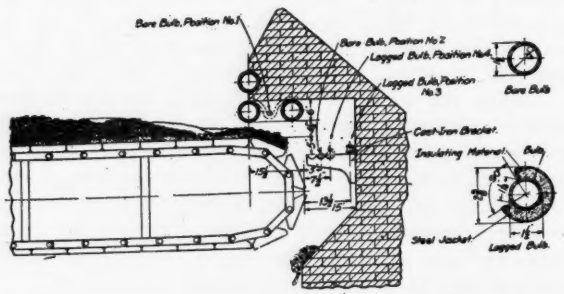


FIG. 2. ASH-PIT LOSS RECORDER ON FORCED-DRAFT CHAIN GRATE STOKER

welded. The bulb is charged with nitrogen and the gas pressure that is exerted by an increase in temperature is conducted through a 3/16-in. copper capillary tube to the recorder. The recorder consists of a simple mercury U-tube, one leg of which is open to the atmosphere and carries a float to which the recorder pen is attached.

The other leg of the U-tube is made up of sections having different cross-sectional areas, so that the pen movement is suppressed below and above the range to be

* Abstract of paper presented at the spring meeting of the American Society of Mechanical Engineers.

recorded on the chart. It is also possible, if necessary, to have the area of one leg of the U-tube variable, so that the percentage of heat loss will be recorded directly with uniform graduations on the chart in case the relationship between the ash-pit loss and temperature should not be a straight line.

Location of Temperature Recorder Bulb in Furnace

Figure 2 shows the location of a bulb at the end of a forced-draft chain-grate stoker. A bare bulb was first located at position No. 1 with cast-iron supports. It was found that when the fuel was up to the bottom of the waterback and there was a slight positive pressure in the furnace, a flame would envelop the bulb sending the temperature up to more than 1500 deg. No data were obtained from this recorder in the No. 1 position.

The bare bulb was next placed on the cast-iron bracket in position No. 2, and after operating several days it was found to be satisfactory as to temperature range and continuous operation. A series of calibration tests was then started to learn what combustible losses corresponded to the different temperature readings.

Relation Between Temperature and Combustible Loss

The essential results obtained and averaged for each hour during tests, representing the conditions existing while taking the 107 samples, are plotted in Fig. 3, where each small circle represents the average of all temperature readings grouped between 300 and 400, 400 and 500 deg. F., etc. It is noted that the ash-pit loss is about 3.5 per cent at 300 deg. and increases 1 per cent for each 100 deg. temperature rise.

Emphasis is usually placed upon the percentage of combustible in the ashes as being the true measure of loss due to unburned carbon, but it is of equal importance to know the percentage of ash in the coal. There is more heat lost with 20 per cent combustible in the refuse from a coal with 20 per cent ash than with 40 per cent combustible in the refuse from a coal with 8 per cent ash.

Temperature Variation

One naturally questions whether the temperature of a bulb at such a location will vary with the percentage of heat lost or with the percentage of combustible in the refuse; whether either relation will hold true for different percentages of ash in the coal, or whether it varies with the boiler rating, grate speed, etc. The final answer to such questions can only be determined from results of actual tests. Figure 3 is plotted from the 107 samples and it shows conclusively that the temperature varies directly with the percentage of the heat of the coal lost in unburned carbon. Various other plots and studies of the individual tests fail to show any tendency for the results to deviate from this curve due to changes in the percentage of ash in the coal, the grate speed, or the boiler rating.

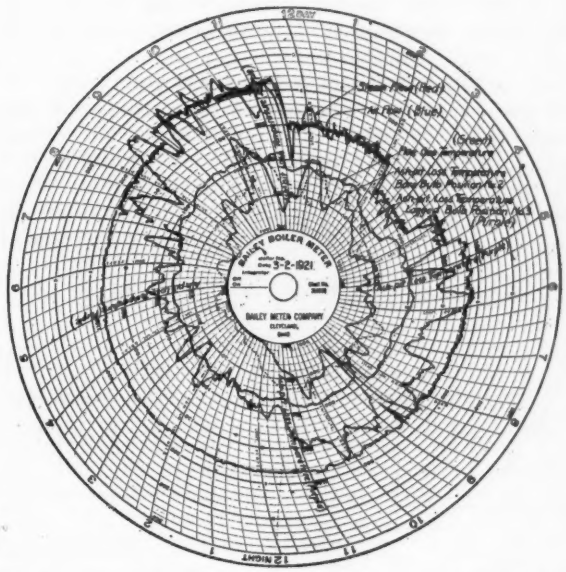


FIG. 5. CHART FROM ASH-PIT LOSS RECORDED ON FORCED DRAFT FURNACE

Figure 5 is a chart record, reduced in size, which shows certain changes in the relationship between the various factors as the stoker operating conditions change. For instance, the average ash-pit loss is greater when the air-flow and steam-flow pens are together than it is when

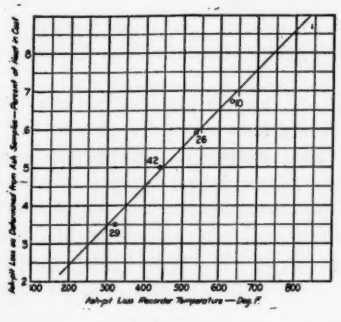


FIG. 3

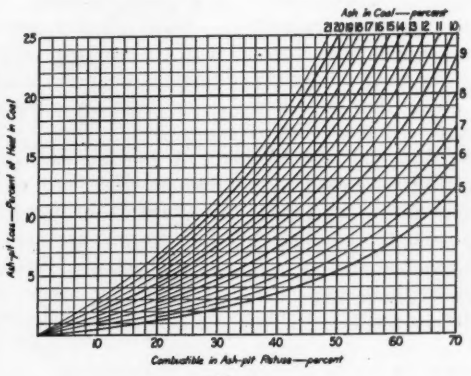


FIG 4

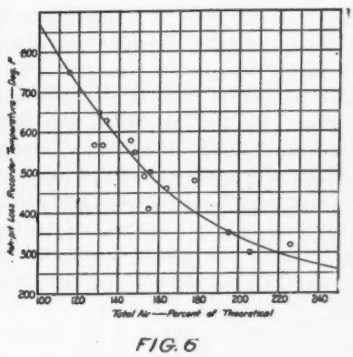


FIG. 6

FIG. 3. ASH-PIT LOSS AND TEMPERATURE RELATION FOR BARE BULB IN POSITION NO. 2 FIG. 2 (NUMBERS REPRESENT NUMBER OF INDIVIDUAL TESTS AVERAGED). FIG. 4. RELATION BETWEEN ASH-PIT LOSS, COMBUSTIBLE IN REFUSE AND ASH IN COAL. FIG. 6. RELATION BETWEEN TOTAL AIR USED AND ASH-PIT LOSS RECORDER TEMPERATURE ON FORCED DRAFT CHAIN GRATE STOKER

the air flow reads more than the steam flow. In this case these two pens are together when the excess air is 40 per cent, and the total air increases with the ratio of air flow to steam flow. During the night when the load is light the air flow was permitted to continue at about 180 per cent of boiler rating while the steam flow went down to 80 or 90 per cent, corresponding to a total air of 300 per cent, or 200 per cent in excess of that required for combustion. During this time the ash-pit loss recorder went to the stop which corresponded to 300 deg. for the bare bulb and a temperature of 300 to 350 deg. for the lagged bulb.

It is well known that with a chain grate stoker the ash-pit loss tends to increase as the excess air is decreased, and vice versa. It is only natural that more coal should be wasted over the end of the grate when the fuel bed is kept thicker and carried to the waterback. When the fire burns short a reduction is made in the ash-pit loss, but there is a decided increase in the percentage of excess air.

The problem is to determine what method of operation will give the lowest total loss, and the ash-pit loss recorded makes it possible to plot out these relations as combustion characteristics of the stoker.

Relation Between Ash-Pit Loss and Total Air Used

Figure 6 shows a very definite relation between temperature as indicated by the ash-pit loss recorder and the total air used for combustion on a basis of the theoretical air being 100 per cent. In plotting the points the total air was taken from the ratio of air flow to steam flow as shown on chart records similar to that of Fig. 5, using only periods when the steam flow, the air flow and the ash-pit loss-recorder temperature were each very uniform over stretches of 2 hr. or more at one time, indicating that the conditions had settled to normal and were not varying continuously as on the chart of Fig. 5. At no time on the latter chart were the conditions uniform enough with respect to these factors to use the results in plotting Fig. 6.

The values taken from the average curve of Fig. 6 are used to calculate the heat losses and are plotted in Fig. 7, showing the characteristic loss curves for a forced-draft chain-grate stoker as operated in Station A. This set of curves shows that the percentage of heat lost in excess air (based on a 500-deg. temperature rise) increases from zero up to 19 per cent at 300 per cent total air. As the excess-air loss is reduced the ash-pit loss increases, but the rate of increase is less than the rate of decrease in the excess-air loss, so the total of these losses decreases until the total air is about 130 per cent. At this point CO and unburned gases appear and the percentage of heat lost in consequence increases very rapidly as the amount of air is reduced to 100 per cent, or the theoretical amount. It is therefore best to operate this stoker at about 130 to 140 per cent total air.

Relation Between Ash-Pit and Total Air

In Fig. 9 it will be noted that the natural-draft chain-grate stoker in question, as it was being operated at this time, gives the best efficiency at about 210 per cent total air, with a loss of 18 per cent due to excess air and unburned coal.

Conclusions

From a study of the data obtained the following conclusions may be drawn:

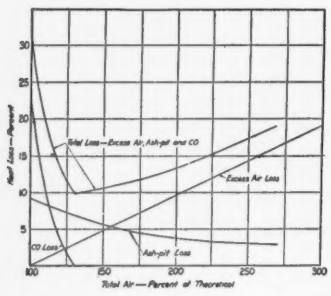


FIG. 7

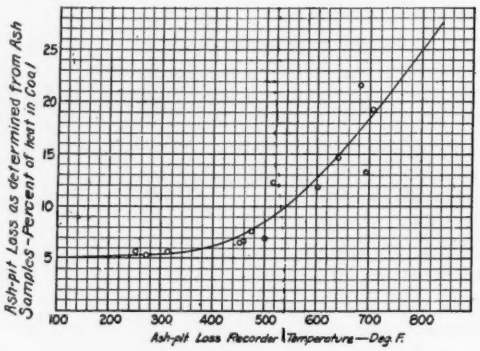


FIG. 8

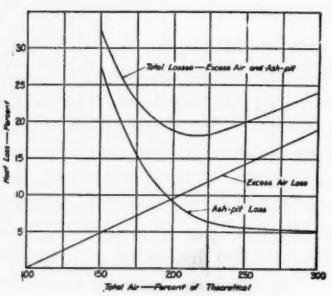


FIG. 9

FIG. 7. CHARACTERISTIC LOSS CURVES ON BASIS OF TOTAL AIR, OF FORCED DRAFT STOKER. FIG. 8. ASH-PIT LOSS AND TEMPERATURE RELATION, BULB LOCATED AS IN FIG. 1. FIG. 9. CHARACTERISTIC LOSS CURVES, ON BASIS OF TOTAL AIR, OF NATURAL DRAFT CHAIN GRATE STOKER

The temperature of a bulb properly located near the rear of a chain-grate stoker responds definitely to changes in amount of combustible going to the ash pit.

The changes in temperature vary in direct proportion to the percentage of heat lost to the ash pit when the bulb is properly located.

This relation between temperature and ash-pit loss is not materially affected by grate speed, rate of combustion, or percentage of ash in coal, but should be determined for different types of installations by actual tests.

A continuous record of the ash-pit loss enables the fireman effectively to control this important factor.

Records of ash-pit loss, excess air, unburned gas, flue-gas temperature, and boiler rating make it possible to plot characteristic performance curves for stokers showing the losses due to unburned combustible, unburned gases, and excess air, and to determine the proper amount of excess air to be maintained and also the most efficient capacity.

These stoker characteristic curves can be used to compare the relative efficiencies of different types of stokers, the suitability of different kinds of coal, and the effectiveness of the control by the fireman.

Boiler Tests with Pulverized Coal*

TESTS AT MILWAUKEE PLANT DEMONSTRATE THAT IT IS NOT NECESSARY TO DRY COAL TO 1 PER CENT MOISTURE NOR TO PULVERIZE IT SO FINE AS FORMERLY THE PRACTICE. BY HENRY KREISINGER AND JOHN BLIZARD

THIS paper gives the summary of the results of a series of 11 tests made on a 468-hp. Edge Moor boiler equipped with a Foster superheater and fired with pulverized coal, at the Oneida Street Station of the Milwaukee Electric Railway and Light Company, Milwaukee, Wis. The tests were made by the Fuel Section of the U. S. Bureau of Mines in co-operation with the Research Department of the Combustion Engineering Corporation. The powdered-coal equipment was designed and installed by the Locomotive Pulverized Fuel Company. The coal burned in these tests came from the Illinois coal field. The object of the tests was to determine what overall efficiency can be obtained with pulverized Illinois coal under various conditions of furnace operation and the different preparation of coal as to degree of fineness and percentage of moisture.

The tests were made in a thorough manner, everything being done to make the results accurate and reliable. The pulverized coal was weighed in specially designed tanks placed on platform scales as it was supplied to the furnace. The tests were of 17 to 25 hours' duration.

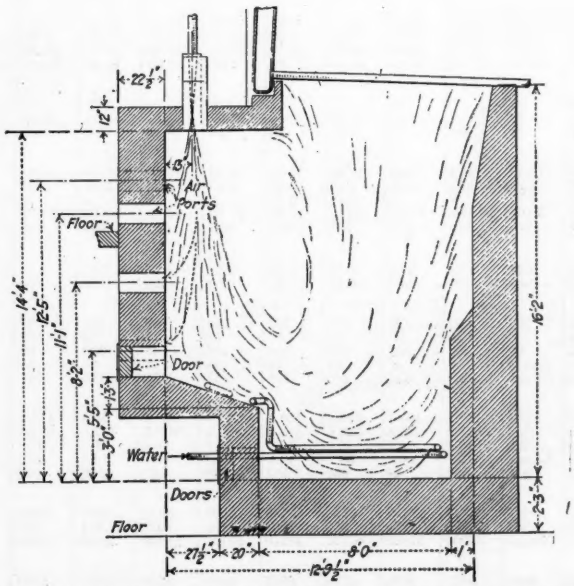


FIG. 1. SECTION THROUGH FURNACE SHOWING ARRANGEMENT OF BURNER AND COOLING COIL OVER HEARTH AND NEAR BOTTOM OF FURNACE

Tests Nos. 28 to 30, inclusive, were made with the usual preparation of coal as it is burned in the plant under ordinary operating conditions. Test No. 31 was made with the same condition of coal as in the three previous tests, but with the furnace provided with a cooling coil over the hearth and along the walls near the bottom of the furnace to facilitate the removal of ash. Tests Nos. 32 to 35, inclusive, were made with the same furnace arrangement as test No. 31, but with the coal pulverized to a lesser degree of fineness. Tests Nos. 36 to 38, inclusive, were made with the same furnace arrangement as in the previous four tests, but with undried coal.

Figure 1 shows the arrangement of the burner and the cooling coil over the hearth and near the bottom of the furnace. The cooling coil consisted of three lengths of 2-in. pipe over the hearth and two lengths along the side walls and the rear wall. The total surface of the coil was 48 sq. ft.

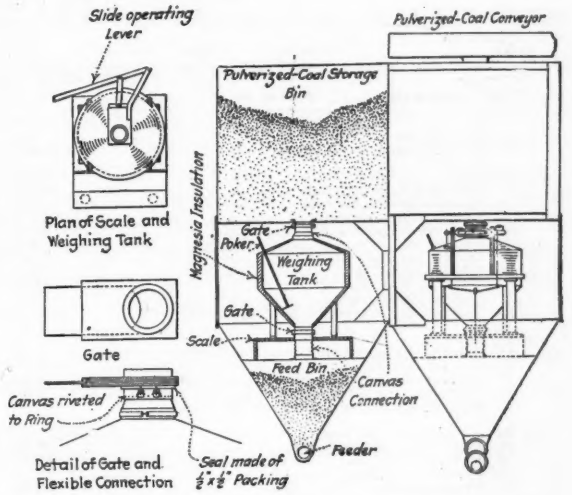


FIG. 2. COAL WEIGHING APPARATUS USED IN TESTS

Figure 2 shows the coal-weighing apparatus, which was placed between the storage bin and the feed bin. There were two burners and two feeders and the coal to each feeder was weighed separately. The weighing tanks were connected to the storage bins and the feeder bin by flexible canvas connections to permit weighing and to prevent the coal dust from escaping into the room when the weighing tanks were filled and emptied. The tests were started and closed with the feeder bins empty.

RESULTS OF THE TESTS

THE RESULTS of the tests are given in Table I. The quantities of heat absorbed by the boiler, superheater and cooling coil, when the latter was used, are itemized separately. In the heat balance the losses by radiation are given by a separate item. In a series of tests on the same boiler and setting the radiation loss per square foot of exposed surface should be nearly constant and should vary only slightly by the capacity developed by the boiler. For the calculation of the radiation loss it was estimated that 250 B.t.u. were lost per square foot of the exposed surface per hour when the boiler was operated at 100 per cent of rating, and 350 B.t.u. when operated at 200 per cent of rating. The radiation loss was calculated according to the percentage of rating developed. These calculations of the radiation loss leave the true "unaccounted for," which consists largely of errors.

* Abstract of paper presented at the spring meeting of the American Society of Mechanical Engineers.

In a series of well-conducted boiler tests this true "unaccounted for" should be close to zero and should vary on both sides of the zero line according to whether the plus or minus errors predominate.

Effect of Fineness of Results of Tests

It has been customary to state that in order to get good results the coal must be pulverized to a fineness of 95 per cent through a 100-mesh screen and 85 per cent through a 200-mesh screen. Table II gives the results of complete sizing tests of the coal burned in Tests Nos. 32 to 35, inclusive. The coal was much coarser than specified by the foregoing statement. The results of these tests seems to indicate that it is not necessary to pulverize the coal to the extreme fineness of 85 per cent through a 200-mesh screen in order to get good combustion and good efficiency. The completeness of combustion seems to be more a matter of proper furnace and burner design and the right way of supplying air, than of the fineness of the coal. The losses due to coarseness of coal would be shown by the greater percentage of carbon in the refuse. The average loss due to this cause for the four

TABLE I. SUMMARY OF RESULTS OF 11 STEAMING TESTS OF AN EDGE MOOR BOILER BURNING POWDERED COAL AT ONEIDA STREET POWER STATION, MILWAUKEE

Heating Surface:
Boiler....4680
Superheater....594
Furnace coil....48
Total heating surface....5322 sq. ft.

Draft — Natural.
Burner — Lopulco vertical.
Coal feed — Screw and air blast.

Rating of boiler....468 hp.
Volume of furnace....1600 cu. ft.
Greatest height of furnace....16.7 ft.
Greatest width of furnace....9.3 ft.
Greatest length of furnace....13.3 ft.

1	Test number	28	29	30	31	32	33	34	35	36	37	38
2	Duration, hours	22.90	23.72	18.17	23.62	23.60	22.47	25.22	23.53	23.43	23.33	16.73
Coal as Fired												
3	Per cent through 100 mesh	96.10	95.80	...	95.40	93.20	93.10	90.80	88.60	....	94.40	95.40
4	Moisture content, per cent	1.42	2.92	2.75	2.55	3.79	3.07	3.60	3.47	7.69	8.23	8.23
5	Volatile matter, per cent	36.62	36.66	37.45	36.58	36.57	36.29	37.17	36.27	35.82	34.42	34.70
6	Fixed carbon, per cent	48.16	46.63	46.08	48.07	48.43	49.01	46.39	48.87	45.74	46.39	44.67
7	Ash, per cent	13.80	13.79	13.72	12.80	11.21	11.63	12.84	11.39	10.75	10.96	12.40
8	Sulphur, per cent	2.66	3.64	3.49	2.92	2.40	2.66	3.43	2.99	2.10	2.21	2.90
9	Calorific value, B.t.u.	11956	11860	11875	12085	12172	12178	11889	12188	11565	11508	11245
10	Total fuel fired, lb.	40214	39862	52746	46613	43947	45469	47459	41250	43729	41640	36315
11	Coal fired per hour, lb.	1756	1681	2903	1973	1862	2024	1882	1753	1866	1785	2171
12	Coal fired per hour per cu. ft. of combustion space	1.10	1.05	1.81	1.23	1.16	1.26	1.18	1.09	1.16	1.12	1.36
Ash and Refuse												
13	Carbonaceous content in furnace slag, per cent	0	0	0	0	0	0	0	0	0	0	0
14	Carbonaceous content in 2d and 3d pass refuse, per cent	4.15	3.49	5.00	5.25	9.52	7.19	7.52	7.37	4.97	4.32	4.49
15	Carbonaceous content in uptake dust, per cent	4.95	5.24	7.35	5.13	7.70	6.45	7.81	5.57	3.91	3.50	3.28
16	Calculated total carbon in refuse, per cent of coal fired	0.50	0.54	0.62	0.36	0.87	0.61	0.67	0.30	0.24	0.22	0.26
17	Softening temperature of coal ash, deg. fahr.	...	2050	2210	2120	2120	2110	2060	...	.....	.....	.....
Ash Account (per cent of ash fired)												
18	From bottom of furnace	29.20	25.50	41.50	48.10	10.10	24.10	37.80	59.40	48.10	47.10	41.60
19	From 2d and 3d pass	12.10	11.60	5.80	10.40	10.30	7.00	9.10	10.50	8.30	7.70	8.70
20	From dust collector	31.50	25.00	33.20	29.20	27.50	29.00	25.50	30.10	32.80	26.00	26.30
21	Unaccounted for	28.20	37.90	19.50	12.30	52.10	39.90	27.60	0.00	10.80	19.20	23.40
Air												
22	Temperature, air at furnace, deg. fahr.	83	90	80	76	85	71	64	74	79	72	75
23	Pressure air at feeder, inches of water	5.00	5.30	7.50	5.10	5.60	5.50	6.40	5.90	5.70	5.50	6.20
24	Excess air in flue gas, per cent	30	22	18	18	19	15	20	25	19	16	20
Flue Gas												
25	Carbon dioxide, per cent by volume	14.10	14.90	15.40	15.50	15.30	15.80	15.10	14.60	15.50	15.80	15.40
26	Oxygen, per cent by volume	4.80	3.80	2.90	3.30	3.20	2.40	3.60	4.10	3.20	2.90	3.60
27	Carbon monoxide, per cent by volume	0	0	0.26	0	0	0.10	0.10	0	0	0	0
28	Pounds of dry flue gas per pound of coal	12.40	11.20	10.60	11.00	11.30	10.80	11.00	11.70	10.70	10.40	10.60
29	Temperature of gases in uptake, deg. fahr.	517	492	610	483	457	472	470	486	484	466	514
Draft												
30	At uptake, inches of water	0.12	0.10	0.27	0.09	0.06	0.08	0.05	0.09	0.10	0.05	0.15
31	Top of furnace, inches of water	0.00	0.02	0.00	0.00	0.01	0.00	0.01	0.02	0.02	0.03	0.03
Steam and Water												
32	Steam pressure, lb. absolute	184	186	196	189	188	187	185	186	183	182	185
33	Degrees superheat	60	59	80	58	53	61	67	79	74	70	102
34	Temperature of feedwater, deg. fahr.	108	99	99	101	101	100	100	103	98	100	99
35	Temperature of water to coil, deg. fahr.	No coil	No coil	No coil	54	53	52	50	48	46	46	46
36	Temperature of water from coil, deg. fahr.	No coil	No coil	No coil	129	146	145	118	151	139	130	144
Rates of Heat Absorption												
37	Per cent of builder's rating (boiler only)	106.6	103.9	167.4	111.7	102.7	112.4	103.4	104.8	101.9	94.4	113.5
38	Horsepower developed (boiler only)	498.8	486.5	779.0	523.2	480.8	526.0	484.0	490.5	477.0	442.0	531.5
39	Horsepower developed (superheater only)	15.8	15.3	32.9	16.3	13.7	15.0	15.4	20.5	18.4	16.3	27.9
40	Horsepower developed (furnace coil)	No coil	No. coil	No coil	49.7	55.0	59.7	45.9	7.5[1]	32.0	29.1	26.8
41	Total horsepower developed	514	502	812	589	549	601	545	528	527	487	586
B. t. u. Absorbed per Sq. Ft. of Heating Surface per Hour												
42	By water in boiler	3567	3482	5575	3743	3437	3758	3466	3503	3413	3207	3798
43	By steam in superheater	892	861	1856	920	772	845	869	1155	1039	934	1573
44	By water in furnace coil	No coil	No coil	No coil	33900	37600	40770	31270	33190	21920	20160	18440
Heat Absorbed per Pound of Coal as Fired, B. t. u.												
45	By water in boiler	9500	9690	8990	8870	8630	8710	8625	9360	8560	8405	8190
46	By steam in superheater	301	304	380	277	246	249	274	391	330	311	430
47	By water in coil	No coil	No coil	No coil	843	995	988	815	335	575	554	414
48	Total absorbed	9801	9994	9370	9990	9871	9947	9714	10086	9465	9270	9034
	Heat Balance (Per cent of heat in coal fired)											
Heat Absorbed												
49	By water in boiler	79.4	81.6	75.6	73.4	70.8	71.5	72.4	76.8	74.0	73.0	72.7
50	By steam in superheater	2.5	2.5	3.2	2.3	2.0	2.0	2.3	3.2	2.8	2.7	3.8
51	By water in coil	No coil	No coil	No coil	7.0	8.2	8.1	6.9	2.7	5.0	4.8	3.7
52	Total and thermal efficiency	81.9	84.1	78.8	82.7	81.0	81.6	81.6	82.7	81.8	80.5	80.2
Heat Carried Away												
53	By dry gases	10.8	9.1	11.4	8.9	8.2	8.6	9.0	9.5	9.0	8.5	9.9
54	By steam from burning hydrogen	4.1	4.3	4.2	4.1	4.1	4.2	4.2	4.0	4.2	4.1	4.2
55	By steam from moisture in coal	0.1	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.8	0.9	0.9
56	By steam entering with air	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
57	By carbon monoxide	0.0	0.0	1.0	0.1	0.1	0.2	0.4	0.0	0.0	0.0	0.0
58	By carbon in ash and flue dust	0.6	0.6	0.7	0.4	1.0	0.7	0.8	0.4	0.3	0.3	0.3
59	By radiation	2.5	2.6	1.9	2.2	2.3	2.1	2.3	2.4	2.4	2.5	2.2
60	Heat unaccounted for	— .3	—1.3	1.6	1.3	2.9	2.2	1.3	0.6	1.4	3.1	2.2
61	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Cooling coil in operation during first 8½ hours of test only.

tests with the coarser coal is 0.7 per cent. The average of this loss for the previous four tests was 0.6 per cent. The averages of the efficiencies are very nearly the same.

The ability to burn coarser coal means increased capacity of the pulverizing mills and decreased cost of coal preparation.

TABLE II. RESULTS OF SIZING TESTS OF COAL BURNED IN TESTS NOS. 32-35

Test No	Percentage of Coal Passing Through Screens			
	20-mesh	40-mesh	100-mesh	200-mesh
32	99.9	99.2	93.2	67.0
33	99.9	99.2	93.1	70.1
34	100 0	98.9	90.8	65.5
35	99.8	98.0	88.6	64.0

Effect of Moisture in Coal on Results of Tests

Another statement that has been generally accepted is that coal must be dried to about 1 per cent moisture in order to be successfully burned in pulverized form. In order to determine to what extent this statement is true, tests Nos. 36, 37 and 38 were run with undried coal. The results of the tests show that the completeness of combustion was as good as with the dried coal. There was no loss due to CO in the flue gases and the losses due to combustible in the refuse averaged only 0.3 per cent for the three tests, which is in fact less than the average with the dried coal.

The losses due to moisture in coal of course increased 0.5 to 0.6 per cent, which increase is at the rate of about 0.1 per cent for every 1 per cent of increase of moisture in the coal. The average decrease in the boiler efficiency for the three tests is about 0.7 per cent, which checks closely with the increase in the losses due to increased moisture in the coal. It seems, therefore, that it is not necessary to dry the coal down to 1 per cent of moisture in order to get good boiler efficiency. In fact, it seems that most of the eastern coals can be pulverized and burned with good results without drying.

Capacity of Boiler That Can Be Developed With Pulverized Coal

The capacity of boiler that can be developed with pulverized coal depends entirely upon the size and shape of the furnace. With the present knowledge of the art of burning powdered coal the best results are obtained when the coal is burned at the rate of 1 to 1½ lb. per cu. ft. of combustion space per hour. Good results can be obtained when the coal is burned at rates varying from ½ to 2 lb. per cu. ft. of combustion space per hour, which gives a considerable working range. In Table I the rate of combustion is given by item 12. The range covered by this series of tests is from 1.05 to 1.81 lb. of coal per cu. ft. of combustion space. If it is desired to operate the boiler at high rates of working, a large furnace must be installed and the combustion space must be so arranged that the flames are given the longest possible path through the furnace. The design of burners and the admission of air are very important at high rates of combustion. It appears probable that future developments in the design of furnaces, burners and the air supply may make possible higher rates of combustion than the limit given above.

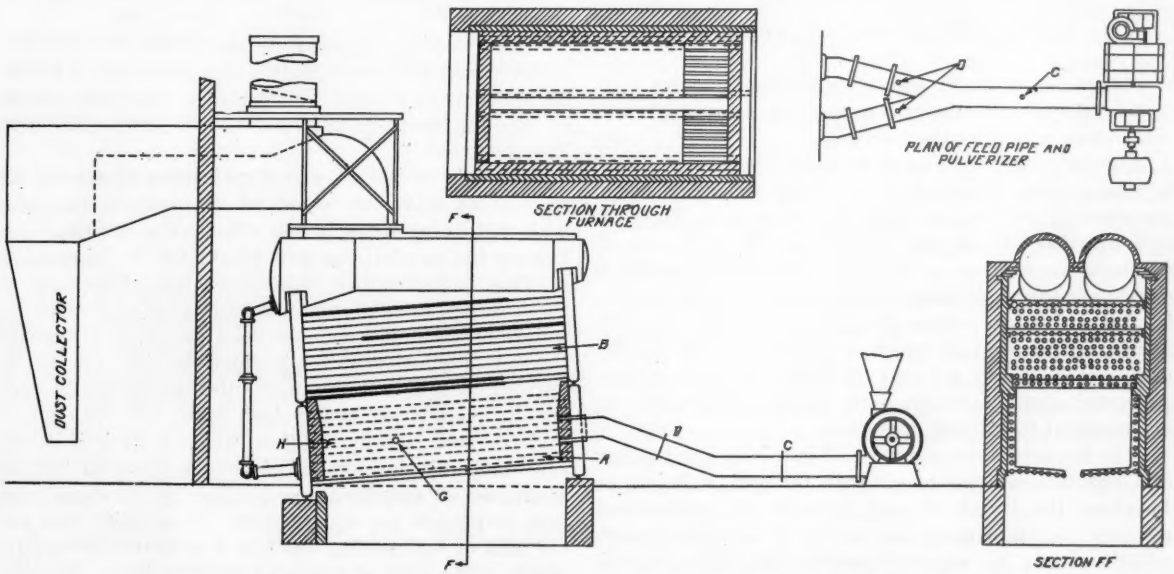


FIG. 3. GENERAL ARRANGEMENT OF ERIE CITY PULVERIZER, BOILER AND STACK

Discussion by Guildford Greig and W. C. Heckeroth

For about 2 yr. the engineering department of the Erie City Iron Works has experimented with, and successfully burned pulverized coal under a 402-hp. Erie City horizontal water-tube boiler at its works at Erie, Pennsylvania.

In the face of much criticism we have persisted in the practice of pulverizing coal of any moisture content, thus eliminating drying equipment. In our experiments we have also found it quite practical to burn the pulverized coal efficiently without reducing it to the extreme fine-

ness heretofore considered necessary, and it is certainly gratifying to find definite confirmation of the practicability of our methods by such eminent authorities as Messrs. Kreisinger and Blizard, authors of the paper under discussion.

The extreme simplicity of our apparatus enabled us to obtain data with a minimum of effort and no mechanical complications, other than those required for an ordinary boiler test complying with A. S. M. E. test code.

As can be readily seen by reference to the illustrations, the only apparatus required by our method of preparing coal for burning in pulverized form other than that required in ordinary stoker fired boiler plants

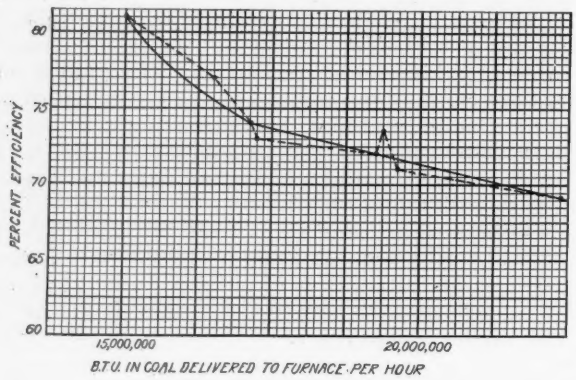


FIG. 4. EFFICIENCY CURVE WITH ERIE CITY EQUIPMENT

is a magnetic separator and a pulverizing machine.

The magnetic separator removes tramp iron from the coal before it reaches the pulverizer.

The pulverizer consists of a cylindrical housing, containing a rotor mounted on a shaft; the roter being composed of pulverizing elements and a fan. The coal of a size that will all pass through a 2-in. ring, and of any moisture content, is fed to the pulverizer through a simple adjustable feeding device which is integral with it. The pulverizer reduces the coal to a powder, approximately 95 per cent of which will pass through a 100-mesh screen, and 85 per cent through a 200-mesh screen. As stated above, however, these degrees of fineness are not essential to efficient operation.

The fan serves two purposes: First, inducing the flow of a regulable volume of air with the coal, sufficient to facilitate the travel of coal through the pulverizer; secondly, to supplement this volume of air with enough additional air to support combustion. This supplemental air is admitted to fan through an orifice in fan housing where air and pulverized coal are thoroughly mixed before being delivered to furnace. Definite regulation of air is easily accomplished by manipulation of adjustable damper on fan housing. All air entering furnace enters in mixture with the pulverized coal and this mixture is delivered to furnace from pulverizer through a plain open ended pipe.

The furnace is of the Seymour type with water cooled refractories which makes it possible to burn pulverized coal with only five to ten per cent excess air, thus reducing stack losses to a minimum.

Referring to illustration it will be seen that the water cooling of furnace refractory lining is accomplished by the circulation of water through tubes and headers disposed in side walls, and walls, and pavement of furnace, which become an integral part of boiler, being connected thereto with pipes and nipples. The pavement of furnace inclines from each side toward the center, thus compelling the movement of the molten slag and ash to the ashpit through an opening in the center of furnace pavement. The ashpit is cooled by the water tubes which form the pavement of the furnace, thus making the ash friable and easily removable. The water cooling of ashpit is a patented feature of this system.

We find the best results are obtained in this type of furnace with a volume of 1¾ cu. ft. per hp.-hr. developed.

During our tests no trouble has been experienced because of slagging of the boiler tubes.

The total power consumption for preparing the coal, and delivering the coal and air to furnace, during these tests, expressed as percentage of fuel burned equals approximately 1.9 per cent.

Exaggerating Losses*

By W. F. Schaphorst

In emphasizing the importance of eliminating losses, the danger of exaggeration is always present. The writer does not wish to belittle losses or to belittle those who exaggerate, but by way of illustration here is an example.

The following statement appeared not long ago in a rather widely read manufacturer's publication and since its appearance in that publication it has been quoted by manufacturers in their zeal to sell certain products. The statement is:

"A ½-in. diameter valve stem leaking all around the stuffing-box will blow about 40 lb. of steam per hour with 100 lb. pressure in the valve. Ten stuffing-boxes leaking for one full day will waste 1600 lb. of coal."

This looked rather gigantic to the writer and on checking up the statement, using Napier's rule that the weight of steam flowing into the atmosphere per second through a given opening is equal to the area of the opening in square inches multiplied by the steam pressure in pounds per square inch divided by 70. Or, to find the area in square inches, which is desired in this case, multiply the number of pounds of steam lost per second by 70 and divide the product by the steam pressure in pounds per square inch. On working this out, the area of the opening was found to be 0.007,78 sq. in., which is the area of a hole about 3/32 in. in diameter.

In other words, each of the 10 stuffing-boxes mentioned above would have to have an unrestricted opening into the atmosphere 3/32 in. in diameter in order to waste 1600 lb. of coal, assuming that one pound of coal will evaporate an average of 6 lb. of steam.

Such a loss as this would hardly be possible unless the stuffing-box contains no packing whatsoever and even if the stuffing-box does contain packing, this tremendous loss is questionable. If the stuffing-boxes contain packing of some kind to restrict the steam flow, the writer asserts that it would be impossible to lose 1600 lb. of steam through a standard well made valve of ½-in. diameter valve stem.

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Relative Efficiencies with Coal and Fuel Oil

COMPARATIVE TESTS SHOW RELATIVE EFFICIENCIES TO BE EXPECTED BURNING TEXAS LIGNITE AND MEXICAN FUEL OIL. BY W. A. DARTER

IT IS a question to every engineer when he faces the problem of changing fuels, whether the boiler efficiency will remain the same and how the total cost of power produced by the new fuel will compare with the cost of production with the fuel previously used.

Description of Boilers in Test.		
	Boiler No. 1.	Boiler No. 2.
Type of Boilers,	Heine,	Heine,
Builders Rating, hp.	300	300
Heating Surface, sq. ft.	2400	2400
Combustion Space, cu. ft.	360	480
Grate Area and Floor Space, sq. ft.	63	160
Type Grate and Oil Burner,	McClave Shaker,	Hammel Burner.
Gas Passages,	2 pass.	2 pass.
Conditions During Tests.		
Av. Steam Pres., lb. gage	150	150
Av. Temp. Flue Gas, deg. F.	525	425
Draft in front of Damper, in.	0.38	0.25
Draft over Fire, in.	0.18	0.05
Av. Temp. Feed Water, deg. F.	190	190
Average CO_2, per cent	7	10
Description of Fuel Used.		
Kind of Fuel Used,	Texas Lignite,	Mexican Fuel Oil.
B. t. u. per Pound of Fuel,	8146	18300
Moisture conteht, per cent	26	0.5
Handling of Fuel,	Hand-fired,	Steam Atomized
Ash, per cent	9	2
Baume' Gravity, deg.	—	15.
Results of Tests		
Fuel Burned Under Boilers, lb	40,050	13,650
Water Metered to Boilers, lb.	186,900	180,900
Water deducted by blowing, lb.	4564	4464
Water Evaporated at 150 lb. gage,	182,336	176,336
Factor of Evaporation,	1.08	1.08
Evap. from and at 212 deg., lb.	197,200	190,200
Evap. per lb. fuel, lb.	4.93	14
Av. Boiler and Furn. Eff. per cent,	59	74
Av. Daily Load, per cent	60	79
Av. Peak Load 8 hr., per cent	105	110
Fuel Lost Through Grate, per cent	2-1/2	—

COMPARATIVE BOILER TESTS BURNING LIGNITE AND FUEL OIL

The cost of the coal and the handling of it, as well as the cost of oil, can usually be determined fairly accurately, but the efficiencies of the boilers for the new fuel cannot always be determined without tests.

The following figures will show the relative efficiencies, burning Texas lignite and heavy Mexican fuel oil. These two tests covered 24 hr. each, and were made under average everyday operating conditions and with the boilers in normal condition. Lignite coal was burned under what we shall designate Boiler No. 1 and Mexican fuel was burned under Boiler No. 2.

These results show that in like conditions it takes 2.1 bbl. oil to equal one ton of lignite coal. The cost of handling lignite coal at this plant is as follows:

Unloading from cars	$0.15 per ton
Ave. load, rolling coal	.20 per ton
Ave. load, fireman	.52 per ton
Total cost	.87 per ton

With these relative boiler and furnace efficiencies we might go a little farther and calculate what we can afford to pay for lignite at the mines. The present contract price on heavy Mexican fuel oil, f.o.b. loading station, is $1.35 per bbl. The freight to the plant is $0.54 per bbl., making a total cost of $1.89 per bbl. According to test, 2.1 bbl. oil is equal to one ton of lignite; 2.1 bbl. times the cost of 1 bbl. is equal to $3.96, which must be equal to the total cost of one ton of lignite thrown into the boiler.

The freight on coal to the plant is $1.20, the cost of handling one ton of coal is $0.87. Deducting the freight and handling cost from the equivalent cost of oil, we have left the cost of lignite at the mines, which is $1.89 per ton.

At the present cost of fuel oil in the open market, the cost of lignite at the mines on the same basis would be $1.04.

Value of Prime Mover Industry

PRELIMINARY report of the census bureau in regard to power prime mover manufacture gives some interesting figures in regard to the industry. The total establishments engaged in producing prime movers are 371, of which the greater part are in the central section of the country. In Ohio, 44; Wisconsin, 36; Michigan, 35; Illinois, 25; Iowa, 17; Indiana, 16; Minnesota, 14; Missouri, 10; Kansas, 5. In the east, Pennsylvania has 34; New York, 31; Connecticut, 16; New Jersey, 15; Massachusetts, 4. In the west, California has 22 and Washington 13. The rest are scattered 1, 2 and 3 in a state.

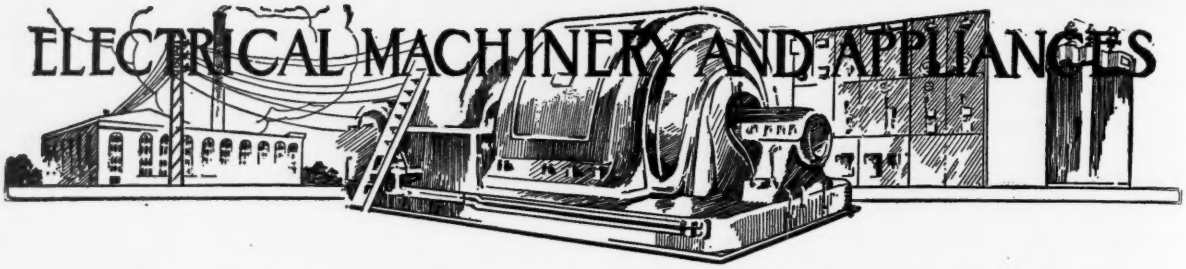
As to product, 60 establishments make chiefly steam engines and turbines; 199, internal combustion engines; 85, traction engines; 17, locomotives; 10, water wheels and turbines. The total value of product for 1919 was $464,770,000.

The single product of greatest value was traction engines, $124,546,000, and the next automobile engines, $58,548,000. Gasoline stationary engines were produced to a value of $37,243,000, and marine turbines to $28,217,000. Marine gasoline engines had a value of $19,153,000, aviation engines, $13,185,000 and stationary gas engines of $10,571,000.

Steam turbines are next on the list with a value of $9,837,000 and steam engines follow at $7,617,000. Hydraulic prime movers were made to a value of $3,308,000. Locomotives are lumped in with other foundry and machine shop products, the total value being $50,953,000, but there is no means of telling what part of this is to be assigned to locomotives.

Figures are not given for the rated horsepower, so that it is impossible to gage the real importance of the various classes as to power production; but it is interesting to note that allowing all the value of the locomotive group to steam, and all the traction engine group to internal combustion, the internal combustion engines had a value of more than twice that of the steam group; and in the stationary field, the gas engines had a value greater than that of the steam turbines.

ELECTRICAL MACHINERY AND APPLIANCES



Design of Industrial Electrical Distrubution Systems---II

CALCULATION OF CONDUCTOR SIZES; AUXILIARY APPARATUS; PERSONAL SAFETY CONSIDERATIONS. BY V. E. JOHNSON

FROM the outline of the conductor system, the length of each section is easily determined if the plan is drawn to scale, or if a dimensioned drawing of the plant is available. The load per feeder is also readily calculated, as in industrial plants the diversity factor need not be considered. Each power feeder must be large enough to take care of the total connected load under any ordinary conditions. This means that the conductor supplying motors must be at least large enough to carry 125 per cent of the name plate rating, while feeders supplying apparatus having no overload capacity (such as heaters of various kinds) must be large enough to carry 100 per cent load. The underwriters have established ratings for each size and for various types of insulation, and these ratings must be adhered to. It must be understood, however, that the values given by them as "allowable carrying capacities" are based only on the heating of the cables and have nothing to do with line losses and economical transmissions. The most economical conductor for a given condition may be either smaller or larger than the underwriters' rating; but if smaller, the "safe" size must of course be used.

Line drop in an a.c. circuit depends on the current flowing and on the resultant of three factors, namely, resistance, reactance and skin effect.

Resistance varies with the length, cross section, temperature and material of the conductor.

Reactance varies with the length, cross section and spacing of the conductors, and also with the characteristics of the current transmitted.

Skin effect is a phenomenon caused by the tendency of alternating current to seek the outside of the conductor, so that the inside copper is not as effective as that on the outside. The effect is that of a reduced cross section of the cable.

The reactance of conductors lying close together as in a conduit is small, and although by no means always negligible, it need not be considered here. The skin effect may also be neglected, as it does not amount to much except in large conductors carrying heavy currents.

DETERMINATION OF CONDUCTOR SIZES

IN THE FOLLOWING methods of determining the proper cross section of the conductor, the effect of reactance and the "skin" effect are not considered, and resistance drop alone is used as the determining factor. This method is quite accurate and will introduce no appreciable error in the design for any plant with which the engineer will ordinarily deal.

The simplest formula so far available is one given in the "American Electricians' Handbook." It is based on a resistance of 11 ohms per circular mil-foot of copper wire at 75 deg. F., and on a balanced three-phase circuit.

$$\text{Circular mils} = \frac{11 \times I \times L \times 1.73}{V} \text{ or simpler, } \frac{19 \times I \times L}{V}$$

where I = current per wire.

L = length of circuit one way.

V = volts drop in the line.

Example: To find size of conductor for carrying 100 amp., 1000 ft. with a voltage loss of 10.

$\frac{19 \times 100 \times 1000}{10} = 190{,}000$ c.m. Table II gives No. 0000 as the nearest available size.

For direct-current circuits, the formula becomes

$$\text{Cir. mils} = \frac{22 \times I \times L}{V}$$ using the same notation. Example I: To find size of wire for carrying 100 amp. 1000 ft. with 10 v. loss; $\frac{22 \times 100 \times 1000}{10} = 200{,}000$ c.m.

TABLE II. DIMENSIONS, WEIGHTS AND RESISTANCES OF PURE COPPER WIRE. B. & S. GAGE

Gauge No.	Diam. Inches	Area: Circular Mils (d²) 1 Mil = .001 Inch	Weight: Lbs. per Mile	Weight: Lbs. per 1000 Ft.	Length: Feet per Lb.	Resistance at 75° F.: Length Feet Per Ohm	Resistance at 75° F.: R Ohms Per 1,000 feet	Resistance at 75° F.: Ohms Per Lb.	Carrying Capacities: Rubber Ins.	Carrying Capacities: Other Ins.	Gauge No.
*	1.153	1000000.	10165.	3050.	.3275	96100.	.01051	.000008423	650	1000	
*	1.035	800000.	12932.	2440.	.4100	76100.	.01313	.000005380	550	840	
*	.963	700000.	11315.5	2135.	.4680	66600.	.01501	.000007030	500	760	
*	.891	600000.	9699.	1830.	.5460	57100.	.01751	.000009579	450	680	
*	.819	500000.	8082.5	1525.	.6550	47500.	.02101	.00001376	400	600	
*	.728	400000.	6466.	1220.	.8200	38050.	.02627	.00002155	325	490	
*	.590	250000.	4038.8	762.	1.32	23750.	.04208	.00005600	240	350	
0000	.4600	211600.	3275.56	620.3	1.56	20085.	.04906	.00007678	225	325	0000
000	.4096	167805.	3677.01	507.0	1.97	16165.	.06186	.00012089	175	275	000
00	.3648	133079.	2123.03	402.0	2.49	12820.	.07801	.00019423	150	225	00
0	.3248	105538.	1683.38	318.8	3.14	10166.	.09838	.00030300	125	200	0
1	.2893	83694.	1335.21	252.8	3.99	8062.8	.12404	.00048994	100	150	1
2	.2576	66373.	1058.85	200.5	4.99	6393.7	.15640	.00078045	90	125	2
3	.2294	52634.	839.68	159.0	6.29	5070.3	.19723	.0012406	80	100	3
4	.2043	41742.	665.91	126.1	7.93	4021.0	.24869	.0019721	70	90	4
5	.1819	33102.	528.05	100.0	10.00	3188.7	.31361	.0031341	55	80	5
6	.1620	26250.	418.81	79.32	12.61	2529.7	.39546	.0049848	80	70	6
7	.1442	20816.	332.11	62.90	15.90	2006.2	.49871	.0079294	35	54	7
8	.1284	16509.	263.37	49.88	20.05	1590.3	.62893	.012608	25	52	8
9	.1144	13094.	208.88	39.56	25.28	1261.2	.79281	.020043	20	36	9
10	.1018	10383.	165.63	31.37	31.33	1000.0	1.	.031880	25	30	10
11	.0907	8234.	131.37	24.88	40.20	793.18	1.2607	.050822	23	27	11
12	.0808	6529.	104.17	19.73	50.69	629.02	1.5898	.080848	20	23	12
13	.0719	5178.	82.62	15.65	63.91	498.82	2.0047	.12841	17	20	13
14	.0640	4106.	65.48	12.44	80.38	395.60	2.5278	.20322	15	20	14
15	.0570	3256.	51.96	9.86	101.63	321.02	3.1150	.31655			15
16	.0508	2582.	41.24	7.81	128.14	248.81	4.0191	.51501	6	10	16
17	.0453	2048.	32.68	6.19	161.59	197.20	5.0683	.81900			17
18	.0403	1624.	25.92	4.91	203.76	156.47	6.3911	1.3023	3	5	18

With the current and the length of conductor known, the only quantity undetermined is V — the allowable voltage loss. In arriving at a proper value for this, consideration must be given two factors: (a) the effect of line drop (or its result low voltage) on the receiving apparatus, and (b) the effect of the line loss on the economics of the line itself.

Low voltage has a decided effect on the candlepower of lamps—so that it is important that good regulation

be maintained on the lighting feeder. The Wisconsin Rate Commission has ruled that voltage variation must not exceed 3 per cent up or down from an established standard voltage—and this would undoubtedly be a satisfactory and reasonable rule to follow in the case of an industrial plant, for proper illumination is of great importance in increasing output, decreasing spoilage and reducing accidents. Motors are not so sensitive to small voltage changes; on power circuits, therefore, the matter of economical transmission becomes the deciding factor, increasing in importance with the amount of energy transmitted.

It is self-evident that the amount of loss in a line transmitting a given current depends on the size of copper used. If the copper be increased, the losses are decreased; but the saving so effected is offset by the increased interest and depreciation charges on the copper. A theoretical method of determining the most economical relation between these two opposing factors is based on Kelvin's Law, which states in substance that "the most economical conductor is that on which the annual cost of energy wasted is equal to the interest and depreciation on that part of the capital outlay (for the line) that is proportional to the weight of the conductor." The "Standard Handbook" gives the foregoing rule, and contains an excellent demonstration of its derivation.

As a matter of fact, however, there are many good reasons why Kelvin's rule is difficult to apply in actual practices. For instance, it is often difficult to determine just what portion of the capital outlay is proportional to the weight of the conductor. This difficulty is aggravated by the fact that some of these costs do not vary in a smooth curve, for example, the cost of iron conduit changes in steps (one pipe size serving for several sizes of wire).

Below is given an example of a much simpler method, which can be readily applied.

Find the most economical size of copper conductor to transmit 100 amp., 1000 ft., using 220 v. three-phase current costing 2c per kilowatt-hour. The energy is used for 20 hr. per day and 300 days per year.

Assume arbitrarily a drop of 10 v. as being allowable.

Using formula Circular mils $= \frac{19 \times I \times L}{V}$ we get

$\frac{19 \times 100 \times 1000}{10} = 190{,}000$ circular mils. The nearest commercial size is No. 0000 with a cross section of 211,600 circular mils.

A very simple formula for determining the watts loss in a three-phase circuit is:

$$P = \frac{33 \times I^2 \times L}{\text{circ. mils}}$$

(Note.—For a d.c. or single-phase circuit, this formula becomes $P = \frac{22 \times I^2 \times L}{\text{circ. mils}}$

Applied to our problem, we find the watts lost to be $\frac{33 \times (100)^2 \times 1000}{211{,}600} = 1560$ w. This would make an annual loss of $20 \times 300 \times 1560$, or 9360 kw.-hr., which at 2c would cost $187.20.

3000 ft. of No. 0000 cable would cost	$ 840
1000 ft. 2½-in. conduit would cost	700
Total for conduit and copper	$1540

In order to determine the relative economy of this size conductor, a similar calculation is made for No. 000 wire.

Walls loss = 1960, making annual power loss, $235.20 or an increased loss of $40. 3000 ft. No. 000 cable costs $698; 1000 ft. 2½-in. conduit costs $700; total conduit and cable cost $1398, or a saving in capital outlay of $142, or $14.20 per annum figuring 10 per cent for interest, depreciation and taxes.

Thus, a saving of $14.20 fixed charges has been offset by a loss of $48 in energy. Therefore, No. 0000 is more economical than No. 000.

TABLE III. APPROXIMATE AMPERES PER TERMINAL FOR INDUCTION MOTORS

H.P. of Motor	110 V.		220 V.		440 V.		550 V.	1100 V.	2300 V.
	2-Ph.	3-Ph.	2-Ph.	3-Ph.	2-Ph.	3-Ph.	3-Ph.	3-Ph.	3-Ph.
.5	3.3	3.7	1.7	1.8	.9	1.			
1.	6.	6.5	3.	3.2	1.5	1.6			
2.	10.5	12.	6.	6.	2.6	3.	2.5		
3.	15.	17.	7.5	9.	3.8	4.5	3.5		
5.	27.	30.	13.	15.	6.5	7.5	6.		
7.5			20.	22.	10.	11.	9.		
10.			25.	29.	12.5	14.	11.		
15.			35.	41.	18.	20.	16.		
20.			48.	55.	24.	27.	22.		
25.			54	62.	27.	31.	25.		
30.			70.	81.	35.	40.	32.	18.	8.
40.			95.	109.	47.	54.	44.	21.	11.
50.			110.	127.	56.	64.	52.	27.	18.
75.			165.	192.	83.	96.	77.	39.	20.
100.			215.	248.	108.	124.	100.	50.	25.
150.			320.	366.	160.	183.	147.	80.	40.
200.			410.	475.	205.	237.	192.	98.	49.
250.			510.	590.	250.	290	237.	125.	62.
300.			600.	700.	300.	350.	285.	150.	74.

For single-phase motors, multiply the current per terminal for a two-phase motor by two.

Repeating the same calculation for 250,000 c.m. cable which can be pulled into 2½-in. pipe we find

Energy loss per year	$ 158
Cost of cable and conduit	1708

Compared to No. 0000 the increase in investment is $1708 — $1540 = $168, with an annual fixed charge of $16.80. Saving in power loss $187.20 — $158 = $29.20.

Thus an increase of $16.80 in fixed charges has effected a saving of $29.20 in energy.

Repeating the calculation for 300,000 c.m. cable which requires 3-in. pipe gives figures as follows:

Annual loss of energy	$ 132
Cable and conduit cost	1978

Compared to the 250,000 c.m. cable the investment has increased $1978 — $1708 = $270, entailing an increase in annual fixed charges of $27. Saving in power lost is $158 — $132 = $26.

Thus an increase of $27 in the annual fixed charges has effected a saving of only $26 in energy. This investment would not be justified, and the 250,000-c.m. cable would be used.

It sometimes happens that for several sizes the saving is zero, that is, the increased cost of copper just equals the energy saved; but the tendency can be determined by carrying the calculations beyond these sizes. Furthermore, if two conductors are equal in economy, the obvious course would be to select the cheaper one.

To serve as a guide in selecting the proper size conduit, Table IV, taken from the American Electrician Handbook, is given.

Having secured economy in operation by careful location of all apparatus and economy in distribution by properly selecting the conductors to be used, the next problem is that of low maintenance cost. This subject, important as it is, cannot be reduced to formulas nor can it be discussed mathematically.

Broadly speaking, economical maintenance is secured by (1) careful selection of the apparatus used; (2) good workmanship in its installation; (3) periodical inspection and prompt repairs. Only the first one comes under the head of design, the others being construction and operation respectively.

TABLE IV. SYNOPSIS OF "WIRE CAPACITY" TABLE FOR MEDIUM RUNS

Size Wire	Size of Conduit	
	2 wires	3 wires
14	1/2	3/4
12	3/4	3/4
10	3/4	1
8	3/4	1 1/4
Stranded Wire from Here on Down		
6	1	1 1/4
4	1 1/4	1 1/4
3	1 1/4	1 1/4
2	1 1/2	1 1/2
1	1 1/2	2
0	2	2
00	2	2
000	2	2 1/2
0000	2	2 1/2
250000	2 1/2	2 1/2
300000	2 1/2	3
350000	3	3
400000	3	3
450000	3	3
500000	3	3 1/2
550000	3	3 1/2
600000	3 1/2	3 1/2
650000	3 1/2	3 1/2
700000	3 1/2	4
750000	3 1/2	4

Based on 600 volt double braid wire in runs of from 150 to 250 feet with not more than four easy bends in the shorter runs or more than one easy bend in the longer runs.

Complete tables can be found in any handbook, and in a great many electrical supply catalogs.

Selection of Apparatus

The selection of apparatus cannot be subjected to any fixed rules. The apparatus should, however, conform to the following specifications:

1. It should be used of a proper size.
2. It should be of a type adapted to the working conditions.
3. It should be rugged and strong.
4. It should be so designed as to permit ready replacement of parts subject to wear.
5. It should be capable of ready inspection.
6. It should be "safe" to use.

As an example, the application of the foregoing principles to the selection of a circuit breaker for use in a dusty location is herewith given.

1. Size—if too small, the contact will heat; if too large, accurate tripping is impossible.
2. A dusty location makes inadvisable the use of an open breaker having laminated brush contacts; an oil breaker should be used. If load has sudden fluctuations, an inverse time element trip should be provided.
3. It should have no pins to shear off nor any weak latches, etc.
4. The contacts should be readily renewable.
5. The tank should be readily removable, and the tripping mechanism should be accessible with the tank in place.
6. The "rupturing capacity" should be great enough to eliminate danger of oil explosions; the case should be grounded.

Metering

The matter of properly metering is worthy of mention, as often an accurate check of current consumption is of help in arriving at factory costs, and in properly distributing production expenses. In providing meters on various circuits the criterion should be, "Will these meter readings be used?"—not as is too often the case, "Can these readings be used?" Money should not be spent to obtain records that serve no practical purpose.

Protective apparatus is another important subject—but lack of space makes it impossible to do anything more than to give the outstanding features of the three classes most commonly found in industrial plants.

Lightning Arresters

The industrial application of lightning arresters is limited to those plants which have an extensive outside system, and to those which are fed from transformers at some distance from the buildings. An arrester to function properly must (1) not respond to moderate increases above normal voltage, (2) have free discharge capacity so as to carry off destructive surges and (3) it must be able to shut off the dynamic current which tends to follow the high voltage discharge.

These problems are met by a number of manufacturers in several different designs; the conditions in an industrial plant are not severe, so that any of these may be safely applied.

Circuit Breakers

These are of either the the open air-break type or of the oil immersed type. The former is suitable for voltages up to 600 and is cheaper than the oil switches of equal carrying capacity. They should not be used under the following conditions:

(1) Rooms full of moisture or acid fumes—as these conditions cause rapid deterioration of the contacts and tripping mechanisms.

(2) Dusty locations. The dust gets between the laminations in the brush type of contact and causes them to "spread"—ultimately producing overheating and reduction of the contact pressure.

(3) Places where explosive or inflammable materials are present in the air. In this connection it may be noted that under the proper conditions almost any kind of dust is explosive.

Fuses

The question of non-refillable versus refillable fuses is still open to argument; the advertising pages of the technical press are filled with conflicting statements of competing manufacturers. Fuses in industrial plants often serve as disconnecting switches, disconnecting branches or feeders to permit repairing.

There is a tendency toward overfusing in most plants, and a great number of circuits have no actual protection, except perhaps against dead short circuits.

Safety

THE ELEMENT of "personal safety" has come within the last few years to be recognized as one of the paramount considerations in electrical installations. It is not enough to provide safe means for performing the various manufacturing operations; it must also be possible to make all repairs without undue hazard to the electricians.

Safe operation and repair is secured by observing the following rules:

1. All live parts of switches should be guarded, either by placing the switch in a box with only the operating handle on the outside, or preferably by using commercial types of "safety switches" that have the door of the box interlocked with the switching mechanism in such a manner that it cannot be opened while the current is on.

2. Panel boxes must have doors with latches and these doors should be kept closed at all times.

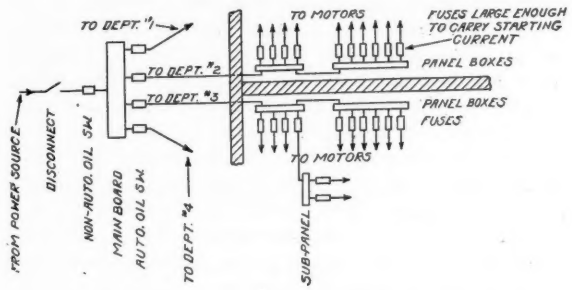


FIG. 8. SHOWING DISTRIBUTION OF ENERGY FROM TWO FEEDERS

3. Metal guards or gratings should prevent access to main switchboards.

4. Crowding should be avoided. Main switchboards should have plenty of room behind them—and the apparatus mounted on them should be properly spaced.

5. All motor frames, oil switch and compensator tanks, switch boxes, etc., should be thoroughly grounded.

6. Means for isolating practically any section of the system should be provided (either by switches or by fuses) so that the electrician will not be required to work on live parts. By providing properly planned sectionalizing devices, the interruption of service can be reduced to a minimum.

7. Accidents due to operating the wrong switch or fuse should be eliminated—first by a logical arrangement of the circuits with reference to the departments or motors supplied, and secondly by adopting a legible and easily understood system of marking.

8. On machinery which is scattered over considerable space (as for example, a paper machine) it may be advisable to have a number of interlocked "push button" stations, permitting emergency stops, without the delay of going to the main board.

Feeder Designs

THE MATTER of feeder layout has already been discussed at some length, but the sketches used did not cover the location of fuses and other apparatus. In order to visualize the various features which have been discussed a schematic sketch is shown in Fig. 8, showing in bare outline the distribution of energy from two feeders.

The fuses indicated are large enough to carry the starting current—and serve as means of disconnecting each motor circuit and as protection against dead short circuits. The motors are protected by automatic trips or by "running" fuses located near the starting box or controller. The "subpanel box" is located near two small motors which, by the nature of their work, always run at the same time. Pulling the main panel box fuses kills both motors. The subpanel fuses protect the small individual motor circuits, while the motors themselves have "running fuses" or trip coils located near their control apparatus. It is generally cheaper to install a "subpanel box" as above (when permissible) than it is to run separate lines for each motor back to the main panel box.

Commutator Brushes for Synchronous Convertors

SUGGESTIONS FOR THE PROPER SELECTION AND USE OF CARBON BRUSHES. BY R. H. NEWTON

SELECTION of suitable brushes for commutator use involves both electrical and mechanical considerations, depending upon the characteristics of the machine in question. From the electrical standpoint, any brush, to be suitable, must have proper contact drop to keep the short-circuit currents under the brush well within control with a minimum brush I^2R loss, when the machine is operating under normal conditions, and, in addition to this, must also have sufficient current carrying qualities to prevent overheating. From the mechanical standpoint, the peripheral speed of the commutator, angle of the brushholder, and whether commutator mica is undercut or not, are all important factors to consider in the selection of a brush with proper characteristics to give long brush life with low friction losses and, at the same time, ride smoothly on the commutator so as to give the minimum amount of noise and vibration. These electrical and mechanical characteristics must all be given consideration in the selection of brushes for any given machine, if best commutation and all around satisfactory operation is to be obtained with a minimum amount of maintenance and upkeep expense.

The service required of a machine is another important factor in deciding the proper grade of brush to select. For instance, railway service with a load factor of 65 per cent during 12 daylight hours and 20 per cent during 12 hr. night service, will obviously permit greater latitude in brush application for a given machine, than where the same machine is applied to electrolytic service with a 98 per cent load factor over the entire 24 hr. of the day.

While it must be understood that every application of brushes for commutator use should be decided only after consideration of all the merits and characteristics involved in each individual case, the following tabulation will be found useful as a reference in approximating most of the average cases:

Carbon graphite brushes are suitable for use on non-undercut commutators, with commutator speeds up to 3000 ft. per min., and brush densities not exceeding 35 amp. per sq. in. This grade of material includes all brushes commonly called carbon brushes. They are com-

posed chiefly of amorphous carbon or coke with only enough graphite added to give the brushes slight lubricating qualities.

Graphitized carbon brushes are adapted for use on undercut commutators with commutator speeds up to 4500 ft. per min., and brush densities not exceeding 50 amp. per sq. in. On apparatus in railway service, with the usual load factors, this grade of brush is applicable on commutator speeds up to 5500 ft. per min. and densities of 55 amp. per sq. in. This grade of material includes brushes which contain considerable graphite in their composition with the balance of amorphous carbon or coke. This class of material usually has a final baking operation carried to a high temperature, which results in modification of the material, leaving most of it in the form of graphite.

Graphite brushes are good for use only on undercut commutators with commutator speeds up to 6000 ft. per

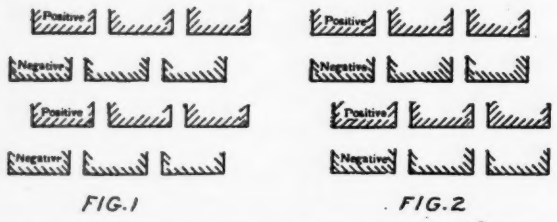


FIG. 1. INCORRECT METHOD OF STAGGERING BRUSHES
FIG. 2. CORRECT METHOD OF STAGGERING BRUSHES

min., and brush densities for all classes of service at heavy load factors and densities of 60 and 65 amp. per sq. in. This grade of material is composed almost entirely of graphite except for a little copper in some cases, and the binding material necessary to hold the particles of graphite together.

Generally speaking, hard or carbon brushes have abrasive or scouring action on commutators, while the softer graphite grades lubricate and give the commutator a good polish. It has been found, however, that graphite brushes often cause bad grooving of the commutator, and when replaced by a harder brush of the graphitized carbon grade this grooving would practically disappear. This has been found to be the case more particularly on older machines where the direct-current brushes were staggered alternately, and the most feasible explanation seems to be that a minute arcing action takes place under the face of the positive (current leaving commutator and flowing into brushes) brushes, which burns away the copper and causes it to be carried across from the commutator to the brush. Small particles of copper imbedded in the face of the brushes will often be found as evidence of this action if examination of the brushes is made.

The incorrect method of staggering brushes is shown in Fig. 1. It will be seen from this sketch that any action peculiar to either polarity is cumulative when all brushes of each polarity are in the same path entirely around the commutator.

The correct method of stagger is shown in Fig. 2. With this arrangement, any action tending to take place under brushes of one polarity will be neutralized, in a way, by the brushes of opposite polarity being directly in line with them. This arrangement gives a more uniform wear over the entire face of the commutator, and thus permits the satisfactory operation of certain grades of brushes where grooving trouble may have been experienced with the incorrect scheme of staggering.

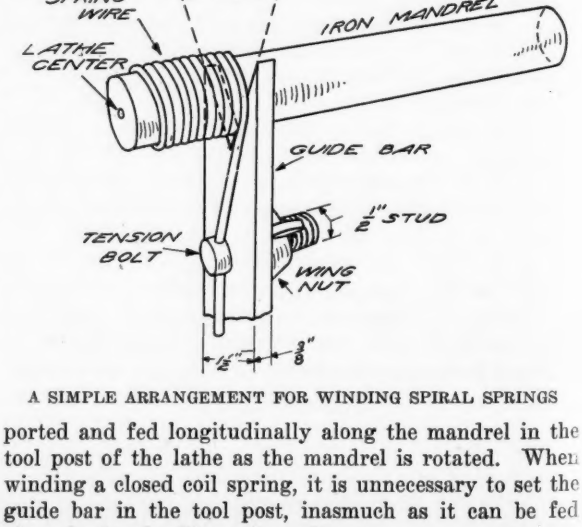
As the progress in design of commutating machines during the past few years has tended steadily toward higher speeds, superior composition in brushes has been required, and the maintenance cost of the apparatus has obviously come to be an item of more consequence than was the case with the older, slower speed, heavier (pounds per kilowatt) machines. It has occasionally been found that although sparkless commutation has been obtained by the use of some particular high-grade graphite brush, objection has been raised to excessive maintenance costs involved, due to the cost of the brushes themselves, and the frequent renewals required, unless the commutator was kept in exceptionally good condition. In several cases of this kind, substitution of a harder graphitized carbon brush has been made and exceptionally satisfactory results obtained. Although usually a change of this kind is accompanied by some slight pin sparking, many operators feel that a compromise involving only a slight sacrifice in the commutating performance of their apparatus is warranted when maintenance costs can be so materially reduced.

In cases where serious commutation trouble is being experienced, an inspection of the apparatus is always desirable in order that a thorough analysis of all conditions pertaining to the operation and service may be made. In cases where trouble is inherent with the brushes alone, and recommendation for a change in grade seems to be necessary, the brush manufacturers retain a staff of capable representatives whose services are always available upon request in all matters pertaining to brush applications.—The Electric Journal.

Winding Spiral Springs

By J. J. Booth

A SIMPLE method of winding sprial springs is shown herewith. The spring wire is wound on the mandrel, which should preferably be set between the centers of a lathe. The wire to be wound on is fed through tension bolt held in a guide bar, which is sup-



A SIMPLE ARRANGEMENT FOR WINDING SPIRAL SPRINGS

ported and fed longitudinally along the mandrel in the tool post of the lathe as the mandrel is rotated. When winding a closed coil spring, it is unnecessary to set the guide bar in the tool post, inasmuch as it can be fed along by hand with good results.

Anticipating Thunder Storms

DESCRIPTION OF READILY ASSEMBLED EQUIPMENT DESIGNED TO WARN STATION OPERATORS OF NEED OF ADDED CAPACITY. BY H. W. SECOR

WHEN electric or thunder storms suddenly rise over the horizon, it frequently requires a tall amount of hustling and firing of boilers in order to cope with the increased lighting load. Especially is this the case when such storms come up in the latter part of a summer afternoon. Under such conditions the load may in a few minutes increase 100 per cent or more.

To fore-arm the central station personnel for such emergency conditions, use is made in Europe and to some extent in this country of a wireless instrument

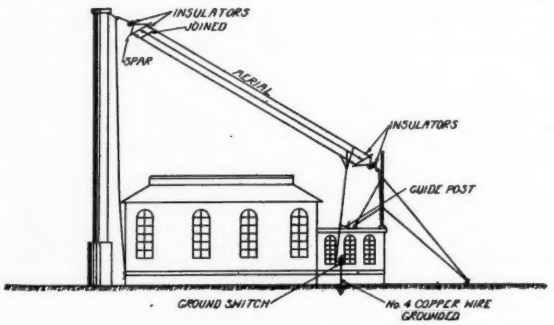


FIG. 1. A SATISFACTORY ANTENNA INSTALLATION

designed to respond to lightning flashes when they are 4 or 5 mi. away. To pick up the ether waves produced by the powerful electrical discharge we call "lightning," it is necessary to erect a fair altitude antenna or aerial of copper wires. This arrangement can be suspended in the most convenient location at hand; one idea is illustrated in Fig. 1.

Here the aerial is composed of three or four strands of No. 14 bare copper wire, or seven strands of No. 22 gage phosphor bronze cable, well insulated by insulators placed at the end of each strand and preferably also in each main suspension rope. Most stations have a high stack which will serve to support the aerial at a good height. Tall trees or poles put up for the purpose may be utilized also.

All aerial joints should be soldered. The wires may be spaced 3 or 4 ft. apart. It should not be less than 80 or 100 ft. long, and elevated at both or at least one end 60 or 75 ft. or more. The lead-in terminal is brought down to the insulated bushing or tube shown in Fig. 2. Also, to conform with the Fire Underwriters rules, the lead-in wire is connected to a single-pole, double-throw 100-amp. 600-v. knife switch indicated, so that during thunderstorms the aerial can be grounded thoroughly through the switch specified to earth via a No. 4 B. & S. gage copper conductor. This may be bare or insulated and is run on heavy porcelain knobs. The lightning ground wire No. 4 must be outside the building and may be run through a basement window to the nearest water pipe. Avoid sharp bends and keep it short. An artificial ground can be used if the water pipe is not near enough, making it of a copper plate 4 by 4 ft. buried in damp earth.

This aerial grounding system may sound rather flimsy, but the writer has wide experience with such systems as this, and has been through very heavy thunderstorms. The lightning discharges are noiselessly and harmlessly conducted to earth if the aerial is thus properly grounded, so that it really acts as a lightning rod.

The lead-in of No. 12 or 14 R. C. wire is brought through a heavy insulating tube as shown and the "distinct" ground (water pipe) lead is run as indicated, both on porcelain knobs. The instrument case with coherer, etc., should not be located over 15 or 20 ft. from the lead-in tube.

Now we come to the ether wave receptor, comprising a metal filings coherer, de-coherer or tapper, sensitive relay 1, spark gap, condenser C, and indicating or alarm bell B, actuated through a second relay of common patterns as depicted diagrammatically in Fig. 2.

First comes the coherer. This radio type instrument of Marconi and Branly is shown in detail at Fig. 3. It consists of a hard rubber or other base of high-insulating qualities, on which rest two binding posts. Through these posts slide two 5/32-in. diameter brass rods, one of which is finely adjustable by a spring tension set up between nut A and post B. Rod C is threaded two-thirds of its length with a No. 8-32 thread as seen. Also it is best to put a pin in post B, arranged to slide in a small 1/32 by 1/32-in. key-way cut in rod C, preventing it from turning when adjusted by thumb nut D.

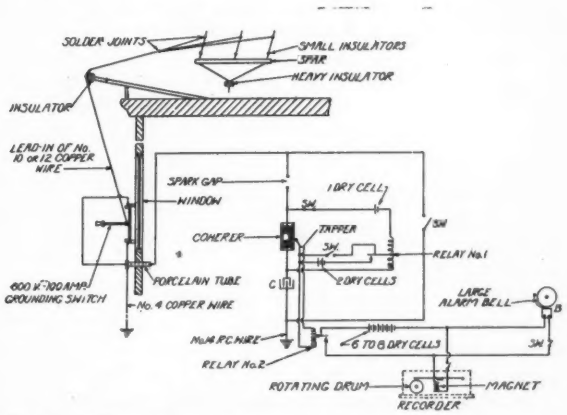


FIG. 2. STATION CONNECTIONS OF LIGHTNING DETECTOR

The ends of the two brass rods facing each other inside the accurately fitting glass tube are usually faced with silver or silver plates. A piece of a dime filed smooth and soldered on proves efficient. Note that it is best to make one or both silver faces on an angle of about 60 deg. to the horizontal axis.

In the space (about 3/32 in. long) left between the metal coherer plugs is placed a small quantity of coarse metal filings, readily made by means of a clean coarse file. Several mixtures of filings have been used. One

mixture attributed to Marconi contains about 90 per cent pure nickel and 10 per cent silver. Another mixture which is widely used for coherers is composed of 85 to 90 per cent steel filings and the remainder of silver. The sensitivity of the coherer is increased by using more silver filings. It will be found best by trial what mixture is best, using a buzzer to actuate the coherer as perceived from Fig. 3-A. The filings must not be touched by the fingers, as the oil on the skin will spoil them. While it is all right to make this part of the apparatus, a coherer and de-coherer of the finely adjustable type may be purchased at a reasonable price.

The coherer is reset or tapped by a vibrating bell (2½-in. gong type) set as seen in Fig. 3 at DE, so that its armature and ball gently tap the glass tube and shake up the filings after each signal, making the coherer ready for the next signal.

The spark gap is detailed at Fig. 4 and is best made of two binding posts screwed to a hard rubber base. Two ⅛ in. diameter brass rods slide through the posts and support the small brass balls as shown. The gap is usually set quite small, or about 1/100 in. A piece of heavy writing paper placed between the balls while they are clamped by the binding posts, will leave a suitable gap, afterward, of course, removing the paper. All connections between the instruments may be of No. 16 R. C. wire, and run so as to cross all wires at right angles as much as possible.

Condenser Construction

Small tinfoil and waxed paper condenser C is made up of three tin foil sheets about 4 by 36 in. with waxed (paraffined) paper leaves between them as Fig. 5 shows. The tinfoil should be ½ in. smaller all around than the paper dielectric. After laying it out flat as the sketch shows, it is carefully rolled up and flattened the same as telephone condensers. It is best to place the rolled condenser in hot paraffine for a few minutes and then in a press or vise, between wooden blocks, until it is cold. Then test with 110 v. d.c. and a lamp to see that there is no connection between the two metal charging surfaces. Connection to the tinfoil leaves is easily made by a strip of copper clamped over them as in Fig. 5, placing an eyelet through copper and foil, which is riveted.

Relay 1 should be a sensitive polarized unit of 500 to 1000 ohms resistance or more. It is feasible to purchase a low resistance relay and rewind it to high resistance with fine magnet wire, such as Nos. 38 or 40 B. & S. gage. Never use more than one dry cell in a coherer-relay circuit. Switches should be placed in all battery circuits. A couple of dry cells in the local or tapper circuit of relay 1 is sufficient. In multiple with the tapper bell is hooked a second relay 2, which may be of the 20-ohm pony telegraph type. This arrangement works best as found by experience, if a second signal circuit with large bell (B, Fig. 2) is to be operated. The dotted circuit shows a recorder attached, which is used in many stations. It can easily be made. A rotating drum covered with paper is moved by clockwork, so it makes one revolution in 24 hr. A line is drawn around the drum at zero coherer action. An electro-magnet moves a pen or pencil over the drum, parallel to its axis, so that a record of all atmospheric disturbances is had for every 24 hr. The magnet coil is mounted alongside of the pen arm and iron armature and not under it as the sketch shows.

A cut-out switch, SW, Fig. 2, is provided to cut out the instrument at any time, while adjusting, etc. During thunderstorms the lightning switch outside the window must be thrown to the "ground" position. This switch is easily worked from inside the power station by a wooden link rod arrangement if desired, rearranging the contacts so the blade moves through say 60 deg. only for either position.

Operation

In action, the set works as follows: A lightning flash takes place, say 5 or 10 mi. away (or sometimes 15 mi.) which sets up powerful ether waves. These reach the antenna and, reaching the instruments, it will

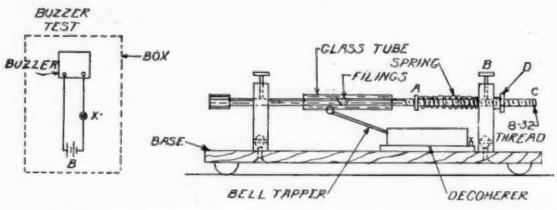


FIG 3A FIG 3

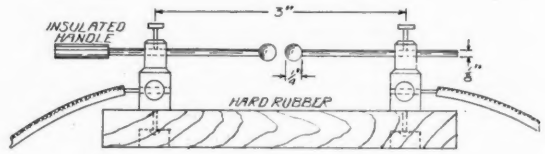


FIG 4

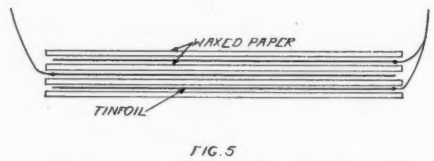


FIG. 5

FIG. 3. COHERER AND DE-COHERER
FIG. 4. DETAILS OF SPARK GAP
FIG. 5. CONDENSER DETAILS

jump the spark gap. Hence it will pass on to earth through the coherer, causing it to actuate the relay 1, etc. Wireless telegraph signals from regular stations will thus be left out, as they will not be sufficiently strong to jump the gap. Local d.c. leak currents are checked from getting into the circuits by the condenser C.

The instrument should be mounted in a glass cabinet and it should be tested at least once a day, and oftener, if convenient. The buzzer (Fig. 3) will serve to test the set. The buzzer battery and push button K are usually mounted in a box. This is held a few feet away from the coherer set. A small spark coil can also be used very efficiently for this work. When the instrument records an alarm, the operating chief should telephone to neighboring towns to ascertain if any electric storms are in the vicinity so as to check the indication given by the instrument.

Increasing Water-Power Plant Efficiency*

Some Suggestions Are Given as to How the Efficiency of Hydraulic Plants May Be Increased. By Charles M. Allen.

IT IS A CURIOUS fact, but one well worth contemplating, that in a large number of manufacturing plants using both steam and water-power, the steam plant usually receives most excellent attention, while the water-power plant gets little if any. Water-power users in such plants do not fully realize that the horsepower developed by the water-wheel is just as valuable as that developed by the steam engine or turbine. Some people seem to think water-power costs nothing after the wheels are installed, perhaps because they do not get a water bill every month, while with a steam plant the monthly coal bill makes a different impression. This applies to isolated plants that own their water rights, for example, a paper mill on a perfectly good water-privilege capable of furnishing the entire power demand of the mill actually takes up from 100 to 200 kw. by steam, simply from lack of attention in operating and properly equipping the hydraulic plant.

The present and probable future high cost of coal and its transportation is at least one perfectly good reason why it is going to pay, from now on, to look after power-plant efficiency. On account of this increased cost of fuel a large number of small water-power sites can be developed and successfully financed today that had to be passed by, only a few years ago.

The first thing to do to increase the efficiency of existing plants is to determine the present operating efficiency. This point has been sadly neglected in the past. In hydroeletric stations it is just as important to know the water input as the watt output, if a plant is to be successfully operated. In these stations the switchboard is usually covered with all kinds of instruments, both indicating and recording, but having to do only with the electrical output. Very little if any apparatus will be found that either records or indicates the water input.

One of the principal causes of low operating efficiency is the improper settings of wheels. It is impossible to make a poor wheel an efficient one by placing it in a good setting, but an efficient wheel can be tremendously crippled by placing it in a poor setting. By setting is meant the intake, casing or flume, draft tube, and tail race.

If after testing, the plant is found to be down in efficiency, a first-class engineer should be consulted. It then becomes a matter of good engineering to determine whether the possible increased efficiency will finance itself. A considerable increase in power and efficiency can be obtained for little or no expense by simply taking as good care of the water-power installations as is ordinarily given to steam-power plants. For example, water-wheels should be inspected every month or two, to make sure that the shafts are lined up, that the runners have the proper clearance and are free from debris. A breakdown can often be avoided and a much higher operating efficiency secured by a continuous, systematic inspection.

Trash racks should be kept free; a considerable loss in head occurs from neglect at this point. This loss in head becomes a greater loss in power because if the wheels were properly chosen for the normal head, any reduction causes the wheel to operate at the wrong speed for best efficiency, especially at part-gate loads.

If old style vertical wheels stand idle during low water periods, the buckets often become covered with tubercles which, unless cleaned, decrease their efficiency from 10 to 15 per cent, and the power from 20 to 30 per cent, depending somewhat on the size of the wheel.

Obstructions in the draft tube and tail race causing water to back up, thus reducing the head, are all too common. Not opening head gates wide enough, owing to a poor rig or laziness on the part of the operators, is a frequent cause of reduced head and is really inexcusable.

If the head gates are used frequently, as they should be in most plants, power-operated gates of some sort should be installed. They should pay for themselves in a short time, not only in the saving of labor, but in the increased efficiency of the plant due to more frequent inspections. If wheels are shut down any considerable length of time on account of low water, the head gates should be closed and cindered to prevent all possible leaks. The wheel gates are not usually tight enough for this purpose.

In certain ground-wood mills, tests have shown that wheels are often operated at the wrong speeds for maximum power and efficiency. In some plants, the foremen apparently insist on running the wheels at some definite speed regardless of whether the wheels are designed to run at this speed or not.

Much could be said concerning the use of available flow in plants having several units. In general, the load should be so proportioned as to get the most power out of the water used. The daily operating head should be kept as high as possible except for special reasons, such as peak loads or emergency causes. Many plants are continuously run under reduced head from simple lack of attention or plain ignorance on the part of the operator. A good many operators pull the pond or forebay level down the first thing in the morning and then run under these low-head conditions the rest of the day, and when asked for the reasons apparently have no real ones.

It should also be stated that a large number of water-wheels have been tested and found to be up to and above their guarantee. This is especially true of the more modern large units. Within the last few years several large vertical hydroelectric units under test have shown an over-all efficiency of 90 per cent.

In order to operate existing plants up to their maximum efficiency, more regular attention should be paid to the actual operating conditions of each essential part of the hydraulic layout. Eternal vigilance coupled with common hydraulic horse sense will in a large measure accomplish the purpose.

* Abstract from the Journal of the Worcester Polytechnic Institute.

Public Utility Power Production

STATISTICS prepared by the Department of the Interior, United States Geological Survey, on the production of electrical power and the consumption of fuel by public utility power plants in the United States should be of particular interest to engineers. Referring to the accompanying graph: the lower set of curves represent the average daily production of electrical power per month for the United States.

It will be noticed that production during January and February of 1921 exceeds that of the corresponding months of both 1919 and 1920. The power produced

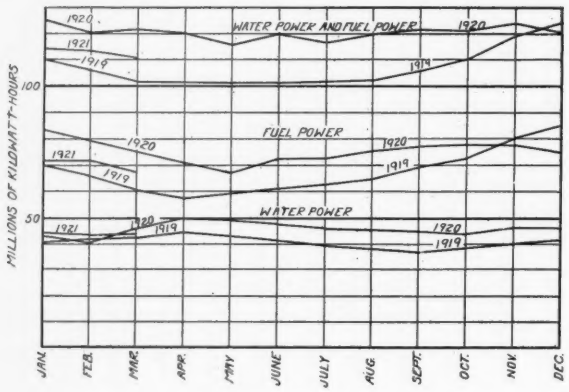


CHART SHOWING AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC UTILITIES FROM WATER POWER, FROM FUEL POWER AND FROM BOTH WATER AND FUEL

from fuel, while less than last year, is greater than 2 yr. ago. The totals of water and fuel power shown in the top curves indicate a relation similar to that for fuel power. The general falling off of the curve from January to March has the same slope as the curves for the last 2 yr. and indicates merely a seasonal fluctuation. The total average daily production for January, 1921, is seen to be 114,400,000 kw. hr. as compared with 125,000,000 kw. hr. for January 1920, a reduction of only about 8 per cent.

This survey further indicates that the states of New York and California are about equal in their use of water power and that they lead the rest of the states by a wide margin. New York leads in power production from fuel. Its total monthly production is approximataely 600,000,000 kw.-hr., indicating a probable capacity of about 2,000,000 kw.

Paraffin Wax in Lubricating Oils

ONE of the refining processes to which lubricating oils are frequently subjected effects a reduction in content of paraffin wax. The actual treatment usually involves chilling and filter pressing; the most important result accomplished from a commercial point of view is lowering of the "cold test" of the oil. The Bureau of Mines has recently had occasion to ascertain the effect of changes in paraffin wax content upon the viscosity of oil and has conducted a series of experiments described in the present report.

The Bureau of Mines has devised and is using a method for the analysis of crude petroleum which includes determination of the viscosities of lubricating oil distallates. The Bureau method does not provide for preliminary removal of paraffin wax, and it has seemed advisable to determine whether this omission causes any important variation from the results that would be obtained through commercial refinery processing. It was also thought that the present tests, though limited in scope, might be of some practical value in indicating the general effect of paraffin content upon one of the most important properties of lubricating oil.

The results obtained show that the indicated viscosity changes are totally unimportant as regards the practice utility of the oils in question, although the accuracy of the viscosity figures is not sufficient to prove that change in paraffin wax content is absolutely without effect on viscocity. The following conclusions were reached:

1. Changes on content of paraffin wax, up to a maximum of approximately 9 per-cent have been shown to cause negligible variations in the viscosity of two Pennsylvania lubricating oil fractions, cut between the respective temperature limits of 250 deg. to 275 deg. C and 275 deg. to 300 deg. C. in the course of a vacuum distillation of 40 mm. reduced pressure.

2. The value of the Bureau of Mines method for determining the viscosity of vacuum fractions from crude oil apparently is not affected by the fact that paraffin wax is not separated from the products that are tested.

3. Variations in content of paraffin wax have a negligible effect upon viscosity through a considerable range of temperature.

4. The present results, although not sufficient to prove a general rule, provide an interesting addition to present information regarding the viscosities of hydrocarbon mixture.—Abstract, Reports of Investigations,U. S. Bureau of Mines.

ANNOUNCEMENT has just been made that the Consolidated Coal Company of St. Louis has placed an order with the Westinghouse Electric & Manufacturing Company for ten motor generator sets with automatic switching and two sets of automatic switching equipment for two motor generator sets already installed. This order includes three 100-kw. sets, six 150-kw. sets and one 300-kw. set, and two sets of automatic switching equipment for two 300-kw. motor generator sets already installed.

The equipment furnished for this order is so arranged that the starting and relay panels will be placed on the surface, the motor generators and d.c. panel located underground. The scheme as worked out requires no control wires between a.c. and d.c. panels, the a.c. power cables being the only connection between the starting panels and the motor of the motor generator; by the proper selection of relays, protection to the set is provided at all times against improper condition of the power circuit, trouble within the set itself, or trouble on the load side. Starting is effected by energizing the high tension line from the power plant through relays which start the several equipments at intervals of 30 sec.

Freight Elevators*

SAFEGUARDING SHAFTWAYS, CABLES, COUNTERWEIGHTS AND OPERATION

MANY serious accidents, some fatal, have occurred on elevators improperly built, inadequately guarded, or carelessly operated, yet nearly all elevator accidents could easily be prevented. Every part of the machine must be carefully designed to carry a specified load on the elevator, and the elevator must never be overloaded.

Shaftway Enclosures

Shaftway enclosures should be such as to prevent persons or materials falling into the shaftway. A solid, substantial enclosure of fire-resisting material is preferable, to prevent both accidents and fire, but if this is not provided, the shaftway should be enclosed to a height of at least 6 ft. above the floor, and above any adjoining stairs. Above all entrance openings, the enclosure should extend to the ceiling, and on the other sides it should be high enough to prevent piled material from falling into the shaftway. Openings in a slatted or wire mesh enclosure should never exceed 2 in., and should not exceed ½ in. at any point where the car or the counterweight passes within 4 in. of the enclosure.

The shaftway, at all open sides of the car, should be smooth and free from protruding objects. Where projections such as floors or beams are unavoidable, a substantial bevel guard, preferably of metal or smooth concrete, forming an angle of at least 60 deg. with the horizontal, should be provided immediately below each projection, and should extend back to the vertical wall or to a point at least 4 in. from the edge of the car platform.

The clearance between the car platform and any landing should be not less than ¾ in. and not more than 1½ in.

Landing Doors and Gates

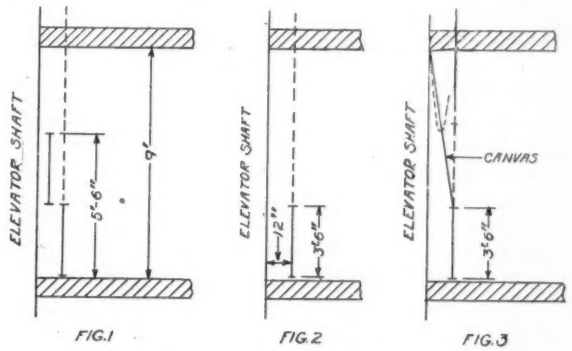
Every landing opening should be equipped with a door or gate, substantial in construction and simple in operation, with openings not exceeding 2 in. between slats or bars.

Horizontally sliding doors should never be used unless an operator is regularly employed on the car. Such doors should be equipped with a self-acting lock which requires a key to open it from the outside. Horizontally sliding fire doors may be provided and kept open, but under such conditions a vertically sliding gate, as described below, should also be provided to prevent persons or materials from falling into the shaftway.

Swinging doors are dangerous because they are likely to be left open, and because in closing they may push persons or objects into the shaftway. Such doors should not be used unless equipped with an interlock or an electric contact, to prevent the elevator from starting until the door is closed. If an electric device is used, it should be connected with an emergency switch in the car, under glass, so arranged that the car can be operated in the event of fire or other emergency, even though the doors are open. Such a mechanical or electrical interlocking device is also recommended for sliding doors.

Collapsible or telescoping gates are likely to get out of order and cannot be recommended; if used, the panels should be made solid or covered with a fine wire mesh to prevent fingers being caught between sections of the gate.

Gates should be at least 5½ ft. high, to prevent persons leaning over the top and being caught by the descending car. Often, however, head room is not sufficient to permit a one-piece 5½-ft. gate; under such conditions a special type of gate may be used, which slides back under the ceiling. If a choice must be made between a collapsible gate 5½-ft. high, and a one-piece



THREE DESIGNS FOR GRATE CONSTRUCTIONS

gate 3½-ft. high, many authorities prefer the latter because of the possibility of the collapsible gate getting out of order. With a low gate, warning chains should be provided. When a gate less than 5½ ft. high is permitted, some laws require it to be set back 12 in. from the shaftway, to lessen the possibilities of a person leaning over the gate and being caught by the descending car. Some members of the National Safety Council, however, object to this position of the gate, because it encourages the man to raise the gate and step out to the edge of the shaftway to reach the operating cable and bring the car from another floor. The provision of a lock on the gate removes this objection. Another means of protection, where a low gate must be used, is a piece of canvas attached to top of gate and to ceiling, folding as the gate rises. The accompanying sketch shows three styles of gate construction.

Gates should, in general, be counterweighted, with counterweights boxed in, or run in guides from which they cannot be dislodged; the bottom of the boxes or guides should be of such construction that the counterweight will be securely held if the rope should break. For heavy gates it is desirable to provide an automatic catching device so the gate will not fall, if the ropes break.

Employes sometimes prop up an elevator gate on a stick to save the labor of frequently opening it. This exceedingly dangerous practice can be prevented by discipline, or by the use of an interlocking device, or by providing a regular operator for the elevator. If the car is not in constant use, the operator may be given other duties near by to occupy his spare time. Employ-

* Prepared by the Engineering Staff of the National Safety Council.

ers report a considerable saving in wear and tear, as well as the elimination of unsafe practices, by placing one man in charge of the elevator, and holding him responsible for its maintenance.

Pits

Every elevator shaftway should have a pit below the lowest landing, extending over the entire area of the shaftway. A pit from 3 to 4 ft. deep is sufficient for freight elevators not traveling more than 150 ft. per min. If the elevator does not run to the lowest floor in the building, or if there is a tunnel or passageway underneath the shaftway, then the pit must be built strong enough to withstand the impact of the car if it drops.

Spring or preferably oil bumpers should be installed in the pit, on a substantial foundation, under the bottom crossbeam of car, and should be of sufficient capacity to absorb, within the limit of their moving parts, all the energy of the car loaded to full capacity and descending at full normal speed. Bumpers should be 12 to 15 in. high when fully compressed, to prevent crushing a man caught in pit.

TABLE OF SAFE LOADS FOR CABLES

- CABLE -		- SWEDISH IRON -			- CAST OR CRUCIBLE STEEL -		
Cable Diam. In.	Least Drum Diam. In.	Factor of Safety 8	7	6	Factor of Safety 8	7	6
		- Safe Load Lb. -			- Safe Load Lb. -		
1/2	20	975	1,115	1,300	2,100	2,400	2,800
9/16	22	1,175	1,345	1,565	2,500	2,800	3,330
5/8	25	1,500	1,715	2,000	3,125	3,570	4,170
3/4	30	2,115	2,415	2,830	4,375	5,000	5,830
7/8	35	2,950	3,370	3,930	5,750	6,570	7,670
1	40	3,625	4,150	4,830	7,500	8,570	10,000

Note: In determining the load on the hoisting cables, where no car counterweight is provided, the weight of the car must be added to the live load or capacity.

The pit should never be used as a thoroughfare, and nothing should be placed in the pit which will require men to work there. No part of the elevator machinery should be placed in the pit, excepting the bumpers and sheaves, nor should any material be stored there. No ropes, wires or pipes should be placed in the pit or in any part of the shaftway, except such as are necessary for the operation of the elevator, and excepting branch sprinkler pipes and heads. If such ropes, wires or pipes are placed in the shaftway, men will occasionally have to work on them, and in spite of all precautions such men are likely to be injured.

Ample illumination should be provided for elevator pits as well as for all other parts of the installation.

Penthouses

Overhead beams should be placed high enough so that, for freight elevators traveling not over 150 ft. per min., the car can travel at least 3 or 4 ft. above the highest landing. Above the beams there should be sufficient headroom, 6 ft. if possible, for the safety and convenience of men inspecting or repairing the machinery or sheaves, which will generally require a penthouse projecting above the roof. The penthouse should be of ample size to permit safe access to and passage around all parts of the elevator machinery, and should be well lighted.

A stairway should be provided, alongside the elevator shaftway, leading from the top floor of the building to the penthouse, or a door should be provided from the penthouse to the roof, so that men will not have to ride upon the top of the elevator car to get into the penthouse.

Cables and Counterweights

Only iron or steel cables should be used for power driven elevators. At least two cables, independently connected, should be used for hoisting and two for each set of counterweights. Wherever possible, an equalizer should be used to distribute the load equally over all cables.

Life of cables will be increased by using the smallest loads given in the table, that is, by using a factor of safety of 8 or more; also by keeping the cables well lubricated. When cables show marked deterioration, amounting to 10 or 20 per cent, they should be replaced.

If steel cables are used, a metal plate bearing the words "Use Steel Cables Only" in large letters should be firmly attached in plain sight on the crosshead, to prevent substitution of iron cables when cables are changed. It is desirable to provide all cables with metal tags indicating the date of installation.

Spliced cables should never be used on elevators, as the splices may work loose in running over the sheaves and drums.

Never use a cable larger than that for which the sheave or drum is grooved, as the cable will become bruised by the improper fit and will wear rapidly.

All power elevators should be equipped with machine counterweights or car counterweights, or both. If two counterweights are placed in the same guides, the car counterweight should be placed above the machine counterweight, with a minimum distance of 12 in. between them. The cables of the lower set of counterweights should be protected against chafing where they pass the upper set of counterweights.

Each set of counterweights should either be contained in a steel frame, or be securely bolted together with at least four bolts, of which at least two should pass through holes in each counterweight. The bolts should be fastened on each end with lock nuts and cotter pins.

If the counterweights are not located within the elevator shaftway, they should be solidly enclosed on all sides. If located within an elevator shaftway which does not have a solid continuous enclosure, the counterweights should be entirely enclosed on the side away from the elevator. The counterweight runways should also be enclosed on the inside, from a point about 12 in. above the bottom of the pit to a point about 8 ft. above the bottom of the pit, for the protection of men working in the pit, in case the car is run to the top of the shaftway thus sending the counterweights to the bottom of the shaftway.

The counterweight guides, as well as the main elevator guides, should be securely fastened and braced to prevent spreading. The top of the counterweight runway should be so arranged that the counterweights cannot possibly be pulled out, if the machine overtravels.

Machine Control and Safety Devices

No power attachment should be applied to any hand-power elevator unless the elevator is made to comply with all requirements of safe practice for power elevators. Every drum type machine should be provided with

a slack cable device which will automatically shut off the power and stop the machine, if the cables slacken or break.

Every drum type machine should be equipped with an adjustable machine automatic limit stop mechanism which will stop the car at the highest and lowest landings, independently of the regular operating mechanism. In addition to this stop, electric elevators should be provided with limit switches, placed in the shaftway and arranged to shut off the motor, apply the brake, and gradually stop the car, if it passes the highest or lowest landing. Limit switches are especially desirable where the car speed exceeds 75 ft. per min. They are, however, of little value unless the machine is equipped with an electric brake.

If the car is driven by polyphase alternating current, and if the phases become accidentally reversed, the car is likely to be driven into the pit or into the overhead work. To prevent this, limit switches should be provided which will open the circuit on all wires, or all except one, and should be so connected that, after the car overtravels, it cannot be moved until the phase reversal is corrected; or, an efficient reverse phase relay should be provided. Such relays should also be designed to protect against single-phasing.

Every electric elevator should be provided with a no-voltage circuit breaker, as well as an overload circuit breaker, or fuse; also with an emergency switch in the car, by which the car may be stopped.

On every elevator controlled by an operating cable, or shipper or hand rope, stop balls should be placed on the operating cable so as to stop the car at the top and bottom landings. Machine automatic limit stops as described above should, however, always be provided in addition to the stop balls. The operating cable should also be provided with a lock on the car, which, when locked, will prevent the operation of the car by persons on other floors.

Every elevator, except direct lift plunger elevators, should be equipped with a catching device attached to the under side of the car which will catch and stop the car if it drops. If the car travel exceeds 12 ft., the catching device should be attached to and operated by a speed governor, set to operate at 40 per cent excess speed. For most types of catching devices, wire governor cable should be used. The catching device should be periodically tested, by tripping the governor by hand while the elevator car is descending or by setting the governor to trip at maximum operating speed and then operating the car at that speed. A catching device alone, without a speed governor, is not sufficient, because it will not stop the car if the machine runs away.

On electrically controlled elevators, the car control switch should be arranged so that it will return to neutral position when released. If there is no operator on the car, it is desirable to provide a lock whereby the control switch may be locked in the neutral position while loading or unloading.

Every elevator should be provided with a signal system or warning bell, which should be so arranged that it may be operated without reaching into the shaftway.

All gears, belts and other danger points should be adequately safeguarded in the same manner as on other machines.

Some Power Plant Troubles

IDEAS FOR MAKING EMERGENCY REPAIRS TO PREVENT SHUTDOWNS. BY H. A. JAHNKE

FREQUENTLY an engineer or fireman in a power plant has trouble with some equipment which, if no remedy is found quickly, may cause a shut-down of the plant until the apparatus is repaired. To do this takes some quick thinking at times.

The writer had an experience some time ago with a 2-in. valve which turns off the water from two large water tanks leading into the factory. One day this valve was closed to make some necessary repairs on this line. After the repairs were completed it was found that the valve could not be opened as easily as before and much strain was used on the lever by one of the helpers in trying to open it. In doing this, the stem was forced out from between the two gates of the valve, as shown in Fig. 1; the location of the valve near the boiler room ceiling is shown in Fig. 2. I suppose that the reason the stem pulled out instead of breaking was because it was worn from long service. To get the valve open, quick action is necessary, as water was needed immediately to keep the plant going. To get the valve open without the stem was a question. I noticed a hammer on the bench and immediately I decided to open the valve in the following way. It will be noticed in Fig. 2 that in order to open the valve the stem had to be pulled down; my idea was to strike the valve body light blows with a hammer in order to loosen the valve gates so that they would drop down. This was done and after a number of blows, the valve was opened and we were out of trouble. The valve was left open until there was an opportunity to replace it with a new one, as it was necessary to close this valve only when repairs be needed on the water line leading into the factory.

Had this valve been in such position that in order to open it, the stem would have had to have been drawn up and it would have been impossible to open it without the stem.

GATE VALVE WOULD STICK

IN ANOTHER instance, a gate valve was used for controlling the water fed from a tank to the boiler room trap. This valve is also located near the boiler room ceiling and a long lever is used for opening and closing the valve from the boiler room floor as shown in Fig. 3. On one occasion, the fireman thought he had closed the valve tight, but he noticed that the trap was still forcing water into the boiler. As the water was getting high in the boiler, he called my attention to the matter. In trying the valve stem, I also thought at first that the valve was closed; but in turning the stem in the opening direction a few turns, then back in the closing direction, I found that it took a good many more turns to close the valve tight than I had turned the stem in the opening direction, which showed that the valve would stick at some point, and as the fireman could not move the stem

farther he thought it was closed, when it was not, as the trap still received some water. This trouble occurred a number of times after this, showing that the valve was worn badly at some place.

As there would not have been an opportunity to repair or replace the valve for some time, I made sure that the valve was closed, then instructed the fireman that when opening the valve the next time he should count the number of turns he made on the stem in the opening direction, then being sure when closing the valve that he made the same number of turns. If this could not be done, the stem should be turned forward and back so as to loosen the gates. This practice was kept up until there was an opportunity to make repairs.

Graphite Causes Uneven Surface on Manhole

An engineer used to complain that he found it impossible to use the manhole gaskets more than once; whenever he made an attempt to use them a second time, no matter how hard he pulled up the plate, the asbestos

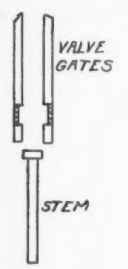


FIG. 1.

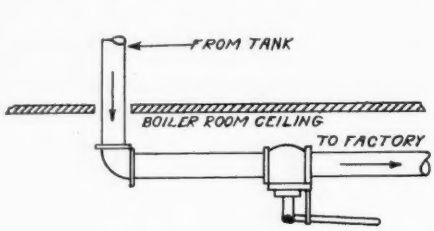


FIG. 2.

FIG. 1. VALVE GATE AND STEM CONSTRUCTION

FIG. 2. LOCATION OF SHUT-OFF VALVE IN FEED LINE

gasket would leak. At times he had trouble in drawing up the plate when a new gasket was used. One day he called my attention to the matter, and on examining the manhole plate surface, I discovered that the surface of the manhole which comes in contact with the gasket was uneven. At first, I thought that this was due to corrosion or some other cause; but on scratching the surface with a knife, I found that this unevenness was caused by the graphite used on the manhole gaskets. Whenever the manhole plate was replaced, the manhole surface was not cleaned, hence the graphite had built up and baked hard to such an extent that it made the surface uneven. When an attempt was made to use the gasket the second time, the plate not being placed exactly in the same position that it was before, i. e., not placed so that the high points on the manhole surface came into the depression in the gaskets where they were before, the gasket would leak no matter how tightly it was drawn up. This was due to the fact that the gasket was much harder now than when new, hence the high points on the manhole would not press into the gasket to make a leak-proof joint.

This unevenness of the manhole surface was also the reason why the plate had to be drawn up so tightly when a new gasket was put on.

I advised the engineer to clean the surface of the manhole thoroughly, then repeat this each time the manhole plate is removed. A new gasket was used and just enough graphite and oil on both sides of the gasket so that it would come off the plate and manhole the next time it had to be removed, without being ruined. After this the engineer had no trouble in using the old gasket over a number of times, without having it leak.

I have seen many engineers and firemen, when placing a gasket on the manhole plate, use as much graphite on the gasket as it would hold without dropping off; this is only wasting graphite and oil, as it does no good. The gasket should only be covered with a thin layer of graphite and oil so that it will not stick to the manhole plate or the surface of the manhole when the plate is removed.

Improving the Oiling System

A high-speed steam engine which is oiled by the splash system gave trouble when one of the main crank shaft bearings received insufficient oil, due to the fact that the crank case was not filled to the limit with oil. I found that the engine was not standing quite level laterally and hence more oil would run to the bearing on the low side. To remedy the trouble, a cock was placed in the oil line leading to this bearing and this cock was partly closed so as to prevent all the oil from going to the one bearing; this would force more oil into the other bearing. In this way, it was not necessary always to have the crank case filled to the limit, which would cause oil to be thrown all over the engine and floor.

It would seem that some engineers care or know little in regard to the care of the machinery under their charge. This engine had run in this condition form any years and I suppose many times the bearing had run dry when the oil in the crank case was a little low and none of the

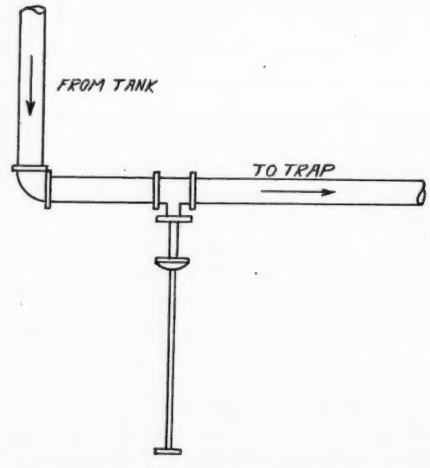


FIG. 3. LOCATION OF VALVE IN WATER LINE TO FEED TRAP

engineers knew or cared to improve the condition, and I suppose that whenever the bearing received no oil the crank case was filled with oil again to the limit.

Ground Joint Union Cured This Trouble

We blow the soot from our boiler tubes with steam each morning. To connect the steam hose to the steam pipe, a standard union is used which requires a gasket. When through blowing the tubes and the hose is disconnected from the steam pipe, the gasket is removed from the union and hung on a nail near the steam pipe ready

for the next tube blowing. Frequently, however, the gasket is not there when wanted; it either was not put there or was knocked off the nail and was lost.

One day while the steam pressure was high and the fire in the furnace just right to blow the soot out of the tubes, I was about to connect the hose to the steam pipe when I could not find the gasket and before I had a new gasket cut and hose connected up, it was necessary to fire up again. Then I decided to eliminate this gasket trouble by installing a ground joint union for connecting the steam hose to the steam pipe.

Blowoff Valve Trouble

One Monday morning, after blowing some of the dirty water out of a boiler, on closing the valve I found it leaked. In opening and closing the valve a number of times I thought I could dislodge whatever was under the valve disc, but could not do this, as the valve kept on leaking. As there was no time to drain the boiler entirely to make repairs on the valve, to refill the boiler again and get up steam pressure in time to get the boiler in operation at starting time, I was up against it for a while. I knew that should I raise the steam pressure the valve would leak worse than it did with the low pressure. I decided to make a temporary repair in the following way:

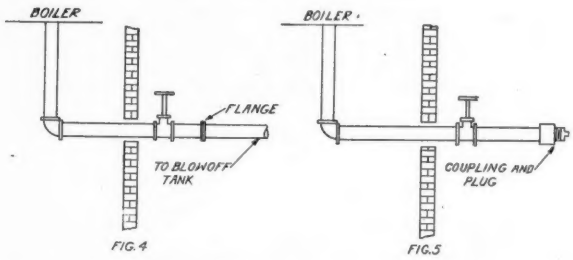


FIG. 4. BOILER BLOW-OFF CONNECTION SHOWING FLANGE JOINT

FIG. 5. NIPPLE PLACED ON END OF PIPE BEYOND VALVE TO PREVENT LEAKAGE

There was a flange near the blowoff valve, as shown in Fig. 4, so I quickly disconnected this flange and screwed the nipple out of the blowoff valve, then placed another nipple in the valve with the other end closed with a coupling and plug as shown in Fig. 5. Of course, after this it was not possible to blow the dirty water out of the boiler mronings and evenings as had been our practice; but boiler cleaning time was to be the following Sunday, so I did not worry much on this account. I suppose that someone will say that it was a dangerous thing to disconnect any parts on a blowoff pipe when there was pressure in the boiler. The pressure, however, was low and I knew the pipe connections on the blowoff tank side of the valve were not tight, as the last time I had made these connections I covered the pipe threads with a mixture of graphite and cylinder oil and did not screw the joints up tight, hence I knew there was no danger. This was the only way I could think of to get the plant started in time.

The next Sunday when the valve was taken apart, I found a small nail imbedded in the valve disc in such a way that it prevented the valve from closing tight. A new disc cured the trouble.

A Peculiar Engine Noise

A clicking noise occurred in the cylinder of a high-speed steam engine, which I could not locate for some time. The cylinder and piston were examined a number of times, but nothing found that possibly could cause the noise.

One day I discovered the cause accidentally. It was my intention to take some indicator cards and find, if possible, the cause of the noise. The indicator pipes are located on top of the cylinder instead of the side as they usually are. When about to remove the plugs from the tee, I noticed that there was pressure in the pipes between the two valves, although they were closed tightly, so I did not remove the plug until the noon hour when the engine was shut down and there was no pressure in the cylinder. After the plug was removed, I examined the two angle valves to see in what condition they were. In removing the bonnet from the valve at the head end, I found that the disc was entirely gone. The discs were of the composition renewable type and I suppose the cylinder oil had softened the disc to such an extent that it fell out of the disc holder piece by piece, in the course of time. The discs were renewed and when the engine was started again to my surprise I did not hear the clicking noise. In thinking the matter over, I came to the conclusion that the leaky valve had caused the trouble, as steam leaked by the valve and as there was more or less water in the pipe between the two valves, the steam coming in contact with this water caused the noise which sounded as if there was a clicking noise in the cylinder.

I believe it is poor practice to use valves that contain discs of the composition type, as in course of time the composition gets soft from the clyinder oil and the valve leaks; it is much better to use valves with solid brass discs which are not affected by oil.

Coaching the Fireman

By Claude C. Brown

Mose was a fireman of the old school. He had fired boilers for the last 30 yr. and up to the present time had always had the opinion that he knew just about all there was to know on that subject. In fact, he was perfectly confident that anybody who could tell him anything about the game would have to be awake pretty early. In this wise, Mose had drifted along from year to year hopelessly mired in a rut from which, to all appearances, there was no getting free. It was not because Mose did not want to advance—it was because the management of the industry regarded the boiler room as a necessary evil, a non-preventable loss, and just as long as Mose had pressure and capacity for the plant to run, he was not bothered. Nobody ever came near the boiler room; it was too dark and black and dirty.

During the stress of war times, however, when practically every industry was taxed to its utmost, there came a time when the demand for steam was so large that Mose could not keep up the pressure and furnish the demand. This certainly was a new situation for him. Never before in all the years of his life as a fireman had this thing occurred. Mose was perplexed; here was a problem that he could not solve; it kept him awake nights, but everything he did from closing

in on the check valves to putting on forced draft was of but temporary relief.

Something had to be done and done fast. The management was falling behind in its output and all on account of the "necessary evil," the uncared for, the all but forgotten boiler room.

Well, something was done and done fast. A competent man was engaged by the management to study the new problem and Mose can tell you what happened: "Ah sho was up agin it! Dem ole boilers what had done stood by me foh yeahs had done laid down when Ah wanted 'em wust. Ah tried ebery trick Ah knowed an' aftah all was said an' done dat steam gage needle jes kep right on goin' down till they slacked up the load on the engine.

"Finally Mistah Jones, the managah, came down heah one day with a young fellah, a mighty nice an' agreeable chap, an' he sez to me, 'Mose, dis heah gen'leman Mistah Smith is going to try an' help you with this boiler problem o' yours', and Ah says, 'Yessah, he sho am welcome.'

"Well, dat boy sho did start right in and he done showed me some things Ah swear Ah nevah would have believed. Fust thing he done was to bring around a contrivance dat he called a 'draft-gage' and he stuck it on all de boilers, one at a time, and fooled wid de dampers till dat contrivance read zactly the same on ebery boiler. Afteh he done dat, Ah noticed dat ole Numbah 1 boiler what am up near de stack, quit ahoggin' all de feed watah. Ah also noticed dat Ah had de feed check valve jes about de same opening on all of 'em.

"While he was doin' dis he stuck a thermometer in de breeching of each one and, Lordy, boy, you should a-seen de difference when he got through. He sho did cut down dat waste heat.

"One day he lighted a match in front of Numbah 6 an' Ah tole him dat was agin' de rules, but he said, 'Watch dis flame!' Den he held it near a crack in de boiler settin' an' lawsy me, dat flame was sucked clean into dat boiler! He done de same thing on all of 'em, so he an' me plastered 'em all up the next day.

"He sez to me one day, 'Say, Mose, how often does you clean your boilers?'

"Now, right den' Ah was doggone ashamed o' mahself cause Ah didn't know what dat boy was talkin' about. Ah says, 'Oh, whenebber we shut de plant down.'

"When he mentioned cuttin' one ob dem boilers out to take a look in it, Ah spoke right up an' says, 'Man, how you all goin' to cut out one ob dem boilers when it's all we can do to get enough steam to run?' an' he says, 'Mose, ain't you been noticing dat day ain't pullin' so hard lately? We will cut out No. 4 tonight,' an' we did.

"Say, what Ah saw in dat boiler! We done took off some of de caps and dey was a number of dem tubes what was plugged up so tight wid scale dat you all couldn't get de stem ob your ole cob pipe in de hole.

"Well, we sho did work on dat boiler, an' den when we got her all slicked up we took out de rest of 'em one at a time an' give 'em de same medicine.

"Now de managah says dat we are turning out more product dan eber and do you know we hab one of dem boilers laid by at all times now? Strange tings does sometimes happen."

System In Your Work

PROPER METHODS TO USE IN PREPARING A PLANT FOR THE SUMMER SHUT-DOWN. BY PERCY BUDD

ONE OF the unpleasant details that sometimes falls to the lot of the engineer in his work, is that of shutting down his plant for the summer months. By shutting down, I mean the preparing of the equipment for a prolonged shut-down and the leaving of it in proper condition.

It is an undisputable fact that this work is not always done in a workmanlike manner, due partly to the fact that the engineer lacks system in his method of handling the proposition, and partly to the fact that a certain amount of personal feeling exists in the engineer's mind when performing this particular job. No engineer ever tackled this sort of job without feeling that he might never have to put the stuff together again.

REPAIR CHART; THE REPORT COVERS THE INSPECTION, CONDITION AND REPAIR WORK OF NO. — BOILER

Boiler Part	Condition	Repairs	Material	Hours	Remarks
Side-Wall In Firebox	Fair, Loose bricks on R.H. wall	R.H.wall from front needs renewing	All fire-brick	4	
Bridge Wall	Bricks badly burned	Renew all wall	Fire brick & common brick	12	
Arch Over Doors	Cracked	New Arch	Prepared arch	8	
Ash Pit	Very good	None		30M	
Crate Supports	Good	None		15M	
Grate Bars	Fair. Two cracked	Renew two grate bars	Two grate bars	2	
Combustion Chamber Brick Work	Good	None		1/2	
Back Arch	Good	None		15M	
Blowoff Pipe In Chamber	Ell Leaking	Renew ell.	One 2 1/2" ell	4	
Pipe Covering In Chamber	All destroyed	Renew	Asbesto rope	2	
Setting Ext.	Good. Slight crack near front	Plug and caulk	Asbesto rope & fireclay	1/2	
Cleanout Doors	All good			30M	
Valves, Safety	Good	None			
Stop	Good	Regrind		2	
Blowoff	Leaks	New plugs	Two plugs 2 1/2"		
Feed	Leaks	Regrind			
Check	Leaks	Regrind			
Water Column	Good	None		1	
Try Cocks	Top leaks	New cock	New 3/4" cock	15M	
Column Piping	Good	None		15M	
Blowdown	Leaks	Regrind		15M	
Cage Glass	Dirty	New glass	1 5/8" glass	30M	
Valves	All good	None		30M	
Steam Piping	Flange leaks	New gasket	Gasket	1 1/2	
Blowoff Pipe	Nipple leaks	Renewed	One 6" x 2 1/2"	5	
Steam Gage	In good order	None		1	Tested
Steam Piping To Blower	Leaking in the joints	Renew piping	4' 1" iron pipe	2	
Heads of Boiler	Good	None		15M	
Tubes	Fair. Two tubes leaking	Renew tubes	2-3 1/2" tubes	4	
Shell	Good	None		1/2	
Seams	All tight	None		1/2	

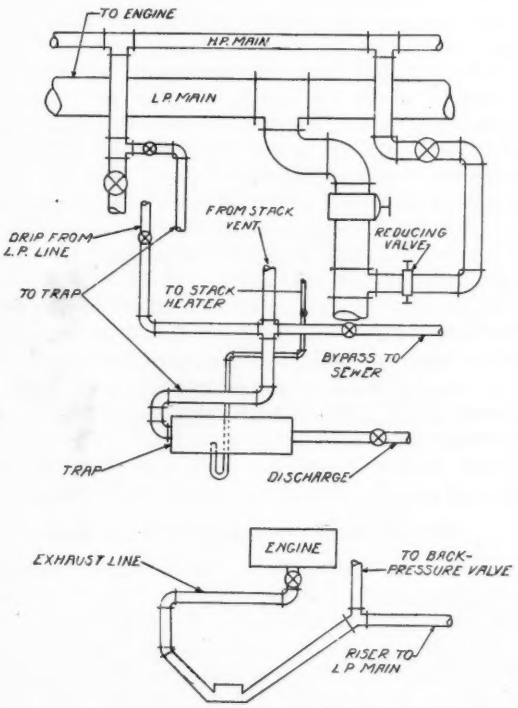
A hydro test of 125 lbs. was applied to this boiler without the boiler showing any weakness or defects

Chief Eng.

The writer was recently offered the job of preparing a small plant for its season's run. The plant had been shut down about 6 mo. and being in a salt water district, nearly all piping in the plant carried salt water. This naturally has a very corrosive action on piping. When the plant was shut down at the end of the preceding season's run, an attempt had been made to drain all piping. Valve caps had been removed, traps taken out, piping opened here and there, and all the plant equipment was taken apart, oiled and greased to prevent corrosion. So far, the method of preventing deterioration was good; but in doing this work, the engineer had overlooked the fact that the equipment had to be put together again this spring.

When the proposition was offered to me, I made a personal inspection of the plant, and I was shocked at the condition of things as I found them. All the equipment had been removed without having provided identification marks or labels, so that the removed parts became nothing more nor less than a pile of junk. Out of 15 traps there were no two alike. In places where piping had been removed, the size and length had to be measured and the particular part for that location sought for in the junk pile.

There was no record of what had been done, or what was to be done. In simple words everything was in a state of confusion. I called upon the engineer who had performed this work, and asked him to come to the plant at my expense, and show me where some of the piping went—piping that I couldn't find any use for, but he admitted frankly that he had not taken enough interest in the work to be able at this time to give me any assistance. This was all due to lack of system.



Steam from engines exhaust at 6 lbs. pressure into L.P. main. H.P. steam passes through reducing valve at 6 lbs. to make up steam when engine does not supply system.

DETAILS OF HEATING PIPING IN STOREROOM

It has in a somewhat variable career been my fortune to have had charge of at least two part-year service plants, and my system in making shutdowns has been as follows: I have always checked up the work as we performed it. Note the boiler chart attached; in this chart, I have taken each part of the boiler and shown what inspection was made, what repairs are necessary, the material used, and the approximate time necessary for one man to do the work.

This chart, when completed, I have filed with my employer, where it can be secured and consulted at the time of getting the plant ready for service again. It forms a history of what was done in the spring, and will be of great value to the man who is called upon to start the plant up again in the fall. This principle can be applied to all equipment in a steam plant.

Still another little detail that helps in the replacing of removed or disconnected pipe lines is a sketch showing just how they were originally. The accompanying sketch shows a detail of one of my heating systems. My method of instructing my help has saved me miles of walking and I generally get the work done as I want it done.

The Metric System in Japan

By J. H. Blakey

AT THE meeting of the French Academy of Sciences on March 29, Mons. Ch. Ed. Guillaume, director of the International Bureau of Weights and Measures, presented a note in which he comments with authority upon the law recently passed by the Japanese Parliament, making obligatory the adoption of the metric system in Japan. The note is as follows:

A telegram from the Director of the Bureau of Weights and Measures at Tokio has just brought the news of the obligatory adoption of the metric system in the Japanese Empire. The importance of this event is seen by a consideration of the extent to which this system is now in use in Asia and in the world generally. In the Far East, legislative enactments have prepared the way in recent years for a change in the local systems of weights and measures, which the different governments are now making obligatory. In Japan, the metric system was legalized on Jan. 1, 1893, when the values of the "shaku" and the "kwan" were fixed at 10/33 of the meter and 15/4 of the kilogram, respectively, and a decimal system was adopted throughout. Later, modification of the law and the promulgation of new rules have brought about the complete adoption of the metric system as it is now in use in Europe.

In China, the passage of the law of 1908 fixed the value of certain units which until then had varied considerably in different trades and localities. The metric equivalents were inscribed in the law and the subdivisions were entirely decimal. A law passed in 1913 in Pekin foreshadows the complete and obligatory adoption of the metric system in a period of 10 yr. In Siam, a law passed in 1912 points to the obligatory adoption of the system, with gradual expansion from one province to another, as instruments and standards are renewed. It will be seen, therefore, that the complete adoption of the system in Eastern Asia is only a question of a few years, as it is now in use in those parts of the continent controlled by France. In the United States, a bill was introduced in the House of Representatives by Congressman Britton, for the purpose of making obligatory the use of the metric system at the end of 10 yr. The opponents of this reform have always considered one of their best arguments that the Anglo-Saxon system of weights and measures was admitted in Japan, China and Siam on a footing of quasi-equality with the local system. The passage of the new Japanese law renders this argument worthless.

Limitations of Mechanical Stokers

MID-WEST COALS PLACE CERTAIN LIMITATIONS ON THE MECHANICAL DESIGN, CAPACITY AND EFFICIENCY OF MECHANICAL STOKERS

AT THE Spring meeting of the American Society of Mechanical Engineers held in Chicago May 23 to 26, two papers of unusual interest to users of coal mined in the Middle West were presented at the Fuel Session. Abstracts of both of these papers are given below, the first under the title Limitations of Mechanical Stokers Utilizing Mid-West Coals was prepared and presented by Edward H. Tenney, and the second entitled Capacity and Efficiency Limitations of Stokers Using Mid-West Coals was prepared by John E. Wilson.

LIMITATIONS OF MECHANICAL STOKERS UTILIZING MID-WEST COALS

A CONSIDERATION of the limitations of mechanical stokers imposed by the use of Mid-West coals is pertinent at this time on account of the increasing application of mechanical-stoker equipment through the Middle West, and on account of the tendency on the part of some to overlook the fact that such limitations exist.

The problem of adjusting stoker operation to any given coal involves three fundamental considerations: Fuel, air supply, and design of furnace. All important limitations to which the operation may be subjected will therefore be found under these heads.

LIMITATIONS IMPOSED BY THE FUEL

MID-WEST coals are classed as bituminous or subbituminous, and are characterized by the higher percentages of moisture, volatile, and ash which they contain as compared with Eastern coals.

The ash content of these coals varies from 10 per cent to 16 per cent, depending upon the method of mining and storing, and presents one of the most difficult limitations to their use on mechanical stokers. Large quantities of incombustible matter interfere with combustion if allowed to remain in the active fuel bed. This is increasingly true at high ratings, especially so on account of the low fusing temperature of the ash, which results in the formation of clinker and the prevention of proper air supply. The efficiency of the combustion process and the effectiveness of the stoker for burning large quantities of coal at high rates of combustion are seriously limited by this clinkering quality in the Mid-West coals.

LIMITATIONS IMPOSED BY AIR SUPPLY

THE SUBJECT of air supply of stokers utilizing Mid-West coals is of equal fundamental importance to that of the fuel itself. Sufficient air, of course, must be supplied to furnish oxygen for the complete combustion of the carbon, hydrogen, and sulphur of the coal. In the burning of low-grade coals the distribution of air through a fuel bed heavy with ash and clinker is not conducive to its proper mixture with the combustible gases, with the result that combustion is incomplete when the gases have passed from the furnace.

LIMITATIONS IMPOSED BY THE DESIGN OF THE FURNACE

THE SIZE of the combustion chamber, in that it determines the length of time during which the mixture of combustible gases and air will remain in the furnace, determines the amount of fuel that can be burned, and hence determines stoker capacity. For high ratings where large quantities of gas are produced and large volumes of air supplied, a limit is reached when the furnace gas and the oxygen in the air supply cannot remain in contact a sufficient time to completely burn the gases. With 50 per cent excess air and burning at the rate of 50 lb. per sq. ft. of grate area per hour developing to within one-half of one per cent complete combustion of the flue gases, the Bureau of Mines have determined that Illinois coal requires 11.9 cu. ft. of combustion space per sq. ft. of grate area as compared with 4.8 cu. ft. in the case of Pocahontas coal.

Stoker limitations may also be imposed by the arrangement of boiler baffling.

The problem of ignition offers another limiting factor in the operation of stokers using Mid-West coals, especially at high overratings. Furnace design must permit of the concentration of sufficient heat at the point of entrance of the fuel to accomplish a rapid distillation and strong ignition of the hydrocarbons. The necessity for, and the practice of, installing a properly designed reflecting arch to accomplish this is well known.

EFFECT OF LIMITATIONS ON OPERATION

THE EFFECT of these various limitations in the case of chain-grate stokers utilizing natural draft is that maximum capacity is limited to the burning of from 40 to 45 lb. of coal per sq. ft. per hour, which may be somewhat increased at a large sacrifice in efficiency. Above this rating, however, the ash-pit loss increases excessively and it is almost impossible to maintain ignition. In the case of forced-chain grates the limits as to rates of combustion are considerably higher, and greater flexibility of operation is also obtained through a more definite control of air supply. However, when the coal rate is increased beyond approximately 60 lb. per sq. ft. per hour, clinkers and slag complications make efficient operation difficult. In addition to this, temperature conditions at high ratings become such as to make furnace and brickwork maintenance a serious problem.

In the case of the overfeed type of stoker, operating under natural draft, a coal consumption somewhat less than that obtainable on the chain grate is generally recognized, this being approximately 30 lb. per sq. ft. per hour. Trouble from the avalanching of the fuel bed is reported beyond this rating, resulting in breaks and bare spots within the fuel bed and temporarily limiting both efficiency and capacity. In the application of forced draft to overfeed types of stoker over-ratings may be somewhat extended.

In the case of the underfeed stoker, particularly where equipped with multiple retorts and forced draft, a quick response may be had to all changes in load, resulting in an exceedingly flexible control. For continuous operation the maximum amount of coal which

can be burned successfully seems to be from 900 to 1000 lb. per retort per hour. For high overratings over short periods a combustion rate of 1400 lb. per retort per hour may be established. The limiting features as to capacity and efficiency in the underfeed stoker utilizing Mid-West coals lie mainly in the high ash content of the fuel and its low fusibility, which at high overratings result in clinker formation and sometimes in the fusing over of the entire surface of the fuel bed adjacent to the dump plates. While such conditions are being rectified, combustion is partially suspended, capacity limited, and efficiency low.

Capacity and Efficiency Limitations of Stokers Using Mid-West Coals

The cost of stoker repairs per ton of coal burned depends to a large extent on the quantity of coal consumed per square foot of grate surface, or its equivalent, rather than on the type of stoker used. The average cost of repairs to a number of chain-grate and underfeed stoker installations has been found to be 3.7 cents and 5.4 cents, respectively, the cost of repairs to the fans and air ducts required by underfeed stokers being included in the latter figure. The chain-grate plants mentioned will burn, on an average, 30 lb. of coal per sq. ft. of grate surface per hour, while the underfeed stoker plants will average 550 lb. per retort per hour.

The quantity of steam required for driving stokers, also for draft fans, will vary from 0.3 per cent on stokers using natural draft to 3 per cent where induced or forced draft is used.

Mechanical Stokers from the Standpoint of Efficient Combustion

The saving due to the increased efficiency obtained with stokers over hand firing will cover only to a small extent the fixed charges on the increased investment required by the stokers.

Chain-grate stokers operating under natural or induced draft have been used extensively through the Middle West for a number of years. In supplying coal to the stoker magazine it is the usual practice to feed it from an overhead bunker through chutes. These chutes are either fan-shaped at the discharge end, or hung so as to allow sufficient swing to distribute the coal in the magazine. In gravitating down the chute the various-sized pieces of coal have a tendency to separate from one another. This action causes the coal to be delivered in the magazine with the small coal in the center, increasing in size toward the ends. The result of this is a marked tendency for the fire to burn off unevenly. The use of overhead lorries for weighing coal to the stoker magazine eliminates this condition to a large extent.

A large percentage of the screenings, or slack coal, used on chain grates will pass a ½-inch mesh screen. In some cases this fine coal has found its way to the sieving pit in such quantities as to represent 15 per cent of the total amount of coal fed to the grate. As a rule the sievings are handled in one of two ways; they are conveyed back to the main coal bunkers, or returned directly by hand to the stoker magazine. A comparatively small quantity of this coal on the grates will be sufficient to upset conditions in the furnace, resulting in lower capacity and efficiency.

The most serious fault, perhaps, of the chain-grate stoker is the failure to provide adequate facilities for controlling the air supply to the furnace. Adjustable dampers have been installed on some natural-draft chain grates for this purpose, but the results obtained are only partly satisfactory. If attempt is made to burn the carbon out of the ash, it is found that an increased amount of excess air is admitted through the rear of the grate.

The chain grate disposes of the ash very successfully, even from coals which run high in ash having a comparatively low fusing point. This is a material advantage, as it permits the use of high-ash coal, which is practically valueless on account of clinkers when used on other types of grates.

Operating records from a large number of plants show that an actual operating overall boiler efficiency of 70 per cent is difficult to maintain. This covers plants where natural draft is used and boilers are not equipped with economizers.

Limitations Governing Capacity of Stokers

The capacity is governed principally by the available draft and ratio of total boiler heating surface to the grate area. With a draft of 0.35 in. over the fire and a ratio of heating surface to grate area of 50 to 5 or less, a capacity of 170 per cent of rating should be obtained without any sacrifice in efficiency. When the ratio of heating surface to grate area is around 60 to 1, a capacity of 140 per cent rating is seldom exceeded. This is based on an available draft of 0.35 to 0.40 in. over the fire.

In many instances where the boilers are equipped for induced draft, ratings of 180 per cent to 190 per cent, and even higher, are obtained with chain grates. It is common practice to use economizers in connection with induced draft.

Several different makes of forced-draft link or chain-grate stokers have been placed on the market in the past few years. A number of installations of this type of stoker are to be found in the Middle West. In making provisions for furnishing air under pressure below the fuel bed, wind boxes and dampers were installed in such a way as to divide the fuel bed into several zones.

Underfeed forced-draft stokers in the Mid-West districts have a large number of very satisfactory records to their credit, both from an efficiency and a capacity standpoint. This type of stoker shares the advantage with other forced-draft stokers of being able to bring a boiler up to 250 to 300 per cent rating in a very short time. The nature and quantity of ash in the coal form probably the most important single item governing the successful operation of underfeed stokers. With a heavy fuel bed the tendency is for the ash to ball up and clinker, preventing the carbon from being burnt out in the furnace.

Some types of overfeed stokers have been used with good success in this section. One of the greatest drawbacks to the overfeed stoker for present-day installations is its small capacity range. Where only a limited capacity is required, and suitable coal is available, results that will compare favorably with those from other stokers can be obtained.

Automatic Valve Prevents Loss of Vacuum

SEVERAL YEARS ago I had charge of a plant for operating a small electric street railway system. The plant consisted of a cross-compound, condensing, George H. Corliss engine, belted to a line shaft, from which two 100-kw. bipolar Edison generators were belted. No provision had been made for running high-pressure; there was a branch pipe from the exhaust, extending through the wall of the building, with a blank flange on the end of it, and no valve between the engine and the condenser; the air-pump was located under the floor, beneath the frame, with lever projecting up to the

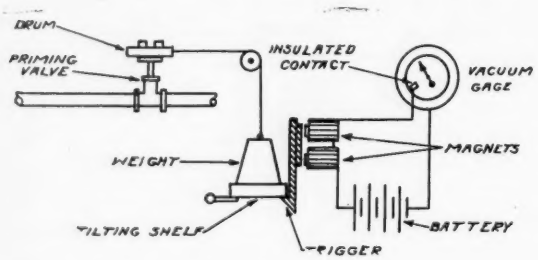


DIAGRAM OF AUTOMATIC VALVE OPENING DEVICE

crosshead, and connected to the low-pressure crankpin by a small connecting-rod. The plant was located on the shore of a small cove where the water was very shallow and we took our condensing water from a reservoir built of square piling. The suction lift was about 15 ft., and at a low course of tides enough water could not be impounded to last over until the next tide and unless we happened to be watching and could get the fresh water injection opened in time, we would lose the vacuum. Then, even though it might be in rush hours, we would be obliged to shut down, disconnect the air pump and remove the blank flange from the free exhaust, and run high pressure until we could get water again, with the exhaust steam blowing through the air pump all the time.

Naturally, I soon got tired of that kind of work. The company would not go to the expense of a condenser valve, and an atmospheric valve, so I evolved a scheme to keep us out of trouble. I made a drum out of wood and bolted it to the handwheel of the priming valve, then put a brass contact plate (insulated) on the dial of the vacuum gage at the point representing 18 in. From the parts of an old arc lamp I got a magnet and a chunk of iron from the scrap for a weight. A strong cord fastened on the drum and passed over a sheave to the weight which sat on a tilting shelf, supported by a sensitive trigger, hung on a knife edge bearing, completed the outfit. Now, when the vacuum dropped to a dangerous point (which in this case was 18 in.) the hand on the gage would close the battery circuit, the magnet would trip the trigger, allowing the shelf to tilt, and the weight in falling would open the valve in time to save the vacuum. Of course we had to "set the trap" again after we got the water but that was far easier than shutting down every time.

M. M. BROWN.

Pump vs. Trap Feed for Steam Boilers

REPLYING to the two interesting letters in the June 1 issue, I am conversant with the operation of return traps, having successfully operated three kinds of them.

In one of my heating systems, all returns are piped to a receiver, which is not and never has been vented to the atmosphere. The condensate is not released from pressure, and its return to the boilers by a duplex pump has never caused the slightest trouble. Whether this pump takes more or less steam does not affect the result, as it all goes into the heating system. The water is very hot, as it passes through this pump. If a trap heats it to a higher degree, it takes live steam to do it. Of this there can be no question. Steam at 2 lb. pressure heats the building in zero weather. There is no vacuum pump or other useless complication. Some of the vacuum systems require 7 lb. pressure to operate them, or 3 lb. above the atmosphere to 5 lb. below it, and there is frequently more or less trouble in their operation.

Since writing my original letter, an engineer in charge of a small plant in this city reports that he has installed a system of return trap feed, and is saving 1½ tons of coal per week by it. I do not entertain the least doubt of the truth of his report, but it only proves one thing to me, and that is that he formerly had a very poor system for doing the same work. No other change was made at this time.

In another small plant in which only one man was employed, the engineer did not fill the bill and was discharged. The new engineer had very different ideas about firing soft coal. The result was that he saved 25 per cent without any change in the load or the plant. Had a return trap been installed just at that time, it would have received all the credit for the saving. The installation of new apparatus usually causes a renewal of interest in the plant, and better service is sure to follow, at least for a limited season.

In many of our pumping systems, the reciprocating pumps are too small for the duty required, hence they must be run at excessive speed, and as a natural consequence they cause a lot of trouble. If one or more of these pumps are superseded by a return trap that is of ample capacity, the result is a great improvement; but that is not a good reason for condemning the entire

pumping system. As long as there is one pumping plant in existence and constant use, in which there is no vent to the atmosphere from the receiver, the pump proves durable, and the whole operates without trouble of any kind, it proves what the system really is. If others are defective in design, or operated without due consideration, the system should not be condemned for it. If any reader wishes to examine such a plant, I shall be pleased to show it. W. H. WAKEMAN.

Observations on Stack Corrosion

THE SUMMER months are the months when corroding stacks can generally be repaired most conveniently because of the favorable weather, the long hours of daylight, light loads and quiet industrial conditions. Mr. Schaefer told in the June 1 issue of Power Plant Engineering how to surround the stacks with concrete. The following observations deal with how to retard corrosion and so delay the day when reinforcing with concrete or new stacks are required.

Interior corrosion is generally more severe, more rapid and less easily detected and prevented than exterior corrosion. Corrosion of the exterior is inhibited by use of the proper paint applied in the proper manner and kept in proper condition, otherwise the elements and the sulphur fumes from the furnace gases will soon start localized attack. How often the exterior of a stack should be painted depends, of course, upon how severe are the corrosive agents. A customary guide is to consider the outside coating of paint in good condition so long as it is comparatively shiny. When it becomes dull when viewed from a distance, the probability is that a new coat of paint is needed.

Preventing interior corrosion is not easy; at best it is a compromise. The effects of the hot flue gases which contain moisture, carbon dioxide and sulphurous acid have all to be contended with and guarded against. The latter are both corrosive in the presence of moisture.

The best safeguard is to line the stack with brick, taking care that the intervening spaces between bricks, and between bricks and metal are thoroughly and completely grouted with cement. Otherwise corrosion will go on unseen; it will be the more serious because it will be localized. Brick linings should always go the full height of the stack because corrosion occurs in the upper as well as in the lower sections. In fact, experience proves that the upper rings deteriorate more rapidly than the lower rings, due, probably, to the greater condensation at the top.

Surprising as it may seem, an unlined stack when taken out of service—and there are thousands of such stacks out of service now—corrodes more rapidly than a stack in constant service. Therefore, the best way to cause corrosion is to take a stack out of service frequently; inversely, the best way to keep an unlined stack from corroding is to keep it working, even though lightly. Another fact that has been noted is that stacks serving banked fires corrode more rapidly than stacks serving active fires, atmospheric conditions being the same in both cases. This is due to the fact that sulphurous acid and carbon dioxide are both corrosive in the presence of moisture; and while a banked fire gives off less of these gases than an active fire, the temperature of the gases is lower and more moisture is present.

Steel stacks should be kept in service on the score of long life. They should also be lined. A lining does more than increase stack life; it reduces the radiation loss through the metallic walls and so improves the draft, an important matter with natural draft in many plants.

Stack corrosion is not of such paramount importance with steam power plants as with many industrial processes where the chemical fumes are virulently corrosive. Where a stack is to be used sporadically or seasonally, however, the question of a brick or concrete stack is worthy of consideration, notwithstanding their higher initial cost. K. RANKIN.

A Stubborn Leak

FIGURE 1 illustrates an engine cylinder made in three pieces. B is the barrel or center piece which telescopes into the ends, being the full length of the bore of the cylinder and bolted onto the end castings at the flanges O and O'. S and S' show the steam valve chests cast on the side of the end pieces. L shows the line of the lagging which is removed and the arrow at P shows

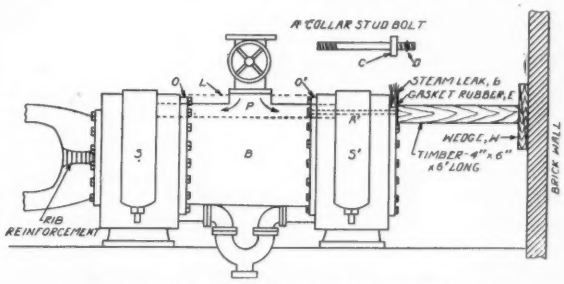


FIG. 1. ENGINE CYLINDER MADE IN THREE PIECES

how the steam passes from the throttle to the steam chests. These end pieces are cast flat on the top and flat on the heads above the cylinder head, and to support the strain on the flat head ends, as well as the cylinder head, it is necessary to use two collar stud bolts as shown at A. The dotted line A' shows how the bolt in position passes through the steam passageway and is tapped into the other side of the end casting at the flange O'. The bolt at the inner end is a flange bolt, not a nut on the end of the collar stud bolt, as would appear in the sketch.

After some extensive overhauling and repair work had been done on this engine, the cylinder head was being put on when one of the mechanics, in tightening the nuts on the cylinder head, twisted off one of these collar stud bolts, after the whole gang had worked 36 hr. on a stretch to get the job finished for running in the morning. No new bolt could be made and it was considered that the adjoining bolts were sufficient to stand the strain, but one was a collar stud bolt also.

For a time the engine ran well without trouble. Then it developed a leak at b, the steam spurting out from the gasket. A piece of timber 4 by 6 in. by 6 ft. long was placed between the cylinder head and the wall with a gasket, E, over the broken bolt and two wedges, w, between the end of the timber and the wall, the wedges being driven in with a sledge hammer while the engine was running until the leak at b stopped.

The engine was run in this manner for a week before it could be spared to put in the new collar stud bolt.

The bolt could not be taken out, as it had to be used to support the strain of this flat end between the collar, C, Fig. A, and the flange, O′, Fig 1, hence it was taken out at the time of breaking and measured for size and put back in place. In tightening it up, it supported more strain than the other collar stud bolt did and left the other collar stud bolt loose between the collar, C, and the flange, O′; but the edge of the other collar extended beyond the face of the flange as at K in part J, Fig. 2. This was partly caused by somebody on some previous occasion putting a gasket at G back of the collar, I. This gasket washer had become eaten out with oil, and with the collar extending as at K tightening up on the nut on the end at X would hold the cylinder head tight to the collar, but not tight against the flange, M, N show the face view of the collar stud bolts in place on the end of the cylinder flange.

It was the bolt M which broke and the bolt N which had the collar protruding with the rubber gasket beneath it, hence two bolts were useless as far as keeping the gasket steam-tight was concerned, and the ticklish part of it was that the flat surface supported by the the bolt N could weave back and forth 1/32 in. until the timber was wedged between the cylinder head and the wall. Had

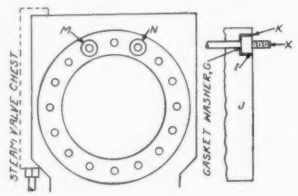


FIG. 2. FACE AND SIDE VIEW OF CYLINDER FLANGE

this flat casting cracked, the result could only be conjectured; but when the new bolt was put in at M the bolt N was taken out and the old gasket washer scraped out and the bolt screwed in solid without any gaskets between the collars and the flat surface which allowed the collars to pass 1/64 in. beneath the surface of the face of the flange, so when the gasket was placed between the cylinder and cylinder head and the bolts tightened up all the way around the collar stud bolts not only supported their full share of the strain on the flat surface of the end of the cylinder, but also clamped the two flanges tight together. In Fig. A, the line D shows where the bolt was broken off.

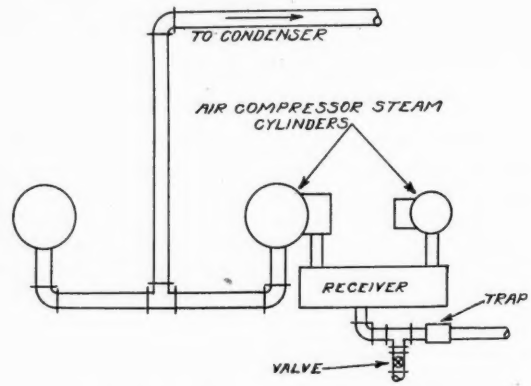
I cannot see how any mechanic or engineer could believe that the rubber gasket washer could be squeezed up tight enough to be solid as iron to iron, which was the intention that the collar should be and as for being steam-tight, the flange gasket more than covered the collar on the outside all the way around, which prevents leakage. This engine runs very nicely and the casual observer would not suspect that the cylinder was in three pieces or that it was a fussy job to keep it in tight running order.

R. A. CULTRA.

Condenser Troubles

FOR SEVERAL years, the operating crews have had trouble starting a cross compound steam-driven air compressor. The steam from the air compressor exhausted into a steam line that was connected to an exhaust steam header. This exhaust steam header supplied steam condensers about 20 ft. above the air compressor, as shown in the sketch.

When the air compressor was started up, there was always hard knocking in the low-pressure cylinder of the steam end, and the compressor had to be run very



LOCATION OF VALVE TO DRAIN RECEIVER

slowly for several minutes. It was discovered that the condensation of the steam in the receiver of the air compressor caused the exhaust steam and condensate to be drawn over back through the low-pressure cylinder and slide valve into the receiver.

The pressure of the exhaust steam of course was not great enough to work the steam trap; hence, to remedy the trouble, a valve was placed in between the receiver and the trap in order that the receiver may be drained thoroughly before the air compressor is started up.

ROBT. TOMACHEFSKY.

Watch the Reboiler

SOMETIMES a principle applied in a different way or for other purposes brings out much more clearly the possibilities for economy or waste than it would as presented to us in our daily contact with it, especially when in the one case we have opportunities for making a quantitative test of the amount of loss.

Several years ago, in fact during the first year of the war, I was called to a distant town to make a boiler test in a plant making guncotton for the Canadian Government. The plant was doing only the preliminary work, the finishing work being done elsewhere.

I got there early Sunday morning and went immediately to the plant where I found only the watchman on duty, and after explaining my business there, proceeded to make an inspection before the engineer came down. The plant consisted of two horizontal return tubular boilers enclosed in steel settings, a small engine running a few pieces of light machinery, three steam-driven deep-well pumps and six open kettles, 10 ft. in diameter by 7 ft. deep, each holding about 1700 lb. of cotton at a charge which required 10 hr. constant boiling to remove the oil. Each vat was equipped with a felt top, all of these discharging to larger ones over the boilers to which the returns were delivered.

I suspected that the trouble was due to the vats and suggested to the manager that his boiler feed pump looked small to carry the load with the returns cut out

as they would have to be, but he thought possibly it could be made to do and was very anxious that a test be made to find out, if possible, the trouble, as they could keep neither steam nor fireman. We made all necessary preparations during the day for a start when the plant would be in operation the next day.

On Monday morning we started up, but it was soon evident that the pump could not take care of enough feed water; in fact, we could not run an hour before the water would be out of sight in the glasses, so this had to be abandoned. And it was immediately evident, as soon as the returns were cut back to the boilers, where the trouble was from the rapidity with which the traps discharged and the easy way in which the boiler feed ran. The traps could not think and with the throttle on the steam lines to the vats wide open, just worked up to the limit of their capacity. The vats were open to the atmosphere and, of course, the more heat applied the more water evaporated without raising the temperature in the least.

We then rigged up a water barrel on a scale and carried the condensate from our trap to this, at the same time weighing in the make-up water to take the place of that evaporated and found they were using nearly 1800 lb. steam per hour per vat. This coupled with the steam used for other purposes was considerably more than the two boilers could care for. I then decided to make a series of short tests covering a period of 2 hr. each, weighing the return and make-up to see how much it could be reduced and yet keep the boiling sufficiently vigorous to get satisfactory results on the material. I soon found by throttling the steam that it was possible to reduce the steam consumption by 40 per cent and still get good results, but it was one thing to get it and quite another to maintain it with the present arrangement, especially as the individual whims and judgment of not too well trained operatives had to be counted on. Some way must be found to keep the flow as nearly constant as possible, so several orifices of different sizes were made in thin plates to go into a union connection and these tried out until we had approximately the same amount of condensate per hour as was found by throttling the steam. As it would be necessary to keep up the boiling I instructed them to make up a lot and every two weeks to make use of the scales to see whether they are beginning to cut out and deliver too much steam.

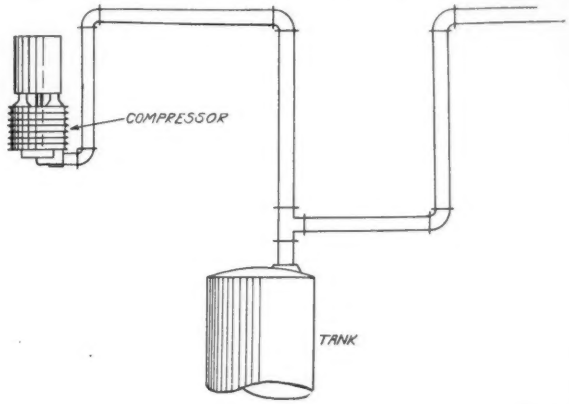
The lesson from this brought out very forcibly the great possibilities for waste in the open reboiler as used in ice plants, only the loss to the ice plant is twofold, not only the great waste in live steam to operate the reboiler, but the loss in distilled water from the condenser.

HOMER JOHNSON.

Air Compressor Troubles

AN AIR BRAKE type compressor working at 110 lb. pressure in an engine room for several years 8 hr. a day without any trouble and only good cylinder oil was used to lubricate the air chamber. One day the oiler, making his rounds, gave it a dose of engine oil which it inhaled and started roaring to such an extent that all working men in adjoining rooms left the building. No damage was done, as the safety valve was large enough to release pressure. The incident, however, should serve as a warning against using a low flash point oil on air compressors.

An air compressor of the air-cooled type was installed to operate at from 80 to 120 lb.; only cylinder oil was used for lubrication and all new standard pipe was used. It worked well for 10 mo. when it began to fail. New rings were put in and valves reground, but to no avail.



PIPING ARRANGEMENT IN WHICH TEE FITTING CAUSED TROUBLE

The piping was tested for leaks, but none were found. Piping from compressor to receiving tank was tried and found O K. Then the pipe from receiving tank to shop was broken and the first nipple 8 in. long was found slugged solid with carbon to the ell and as that was taken off the next section broke off at the joint. Fifty feet of 1-in. new standard pipe was so thin that not a thread could be cut on any part of it although it had had only 10 mo. of service.

The trouble, it is believed, was caused by a pipe fitter's error, in employing a tee, as shown in the sketch to connect the outgoing tank line instead of tapping the tank at different points which would have allowed carbon to settle in the tank, to be blown off at the bottom.

E. G. M.

Packing Friction

IT IS SAFE to say that few engineers realize the amount of friction caused by the modern run of piston and rod packing made largely of graphited rubber and also all kinds of so-called fibrous packing.

There are several ways one can determine the amount of this friction, two of which I have here illustrated. I had a 20 by 48-in. engine having a 3⅛-in. piston rod. I disconnected the rod from the crosshead by unscrewing it; then removing all of the fibrous packing. I found by taking hold of the rod with both hands that I could turn the piston round in the cylinder, thus convincing myself that no undue friction remained. Then I replaced the rod again and set up on the gland quite hard, but it could be harder, then I attached an 800-lb. round spring scale to the piston rod threads, Fig. 3, and also to the crosshead, then attached a piece of chalk to the scale hand so as to register its movement, then the flywheel was moved, which in turn pulled the crosshead which pulled on the scale attached to the piston rod, and when the piston rod started to creep the scales showed a stress of 753 lb. I could hardly believe my eyes, so I undertook to prove it. I disconnected the scales, leaving the rod free to move, then I attached a

new low-pressure steam gage on the indicator pipe at A and admitted steam until the piston rod started to creep. At that moment the low-pressure gage showed 2 2/5 lb., which was the actual pressure required to do what a dead pull of 753 lb. on the scales had done. It was most interesting to see how closely it tested out, as there was 314 sq. in. area in the 20-in. piston which times the 2 2/5 lb. equals the 753 lb. direct pull. This

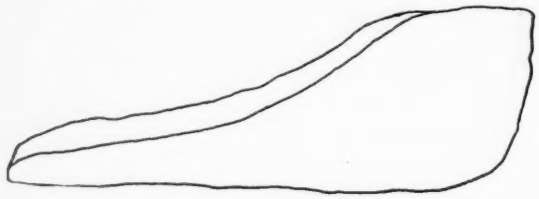


FIG. 1

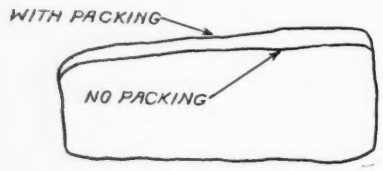


FIG. 2

FIG. 1. INCREASED CARD AREA REQUIRED TO OVERCOME PACKING FRICTION

FIG. 2. INDICATOR CARD FROM PUMP WITH AND WITHOUT FIBROUS PACKING

effect on the engine is bound to be costly, since this 2 2/5 lb. is the same the entire stroke, hence the mean average resistance will take 2 2/5 lb. more mean effective pressure on the propelling side of the piston than it would if there were no packing friction and an engine having a horsepower constant of 6.10 would be wasting $6.10 \times 2\,2/5 = 14.6$ hp. per hr. for every hour it runs.

Indicator cards taken from a drop cutoff engine are illustrated in Fig. 1, also in Fig. 2 is a pump card

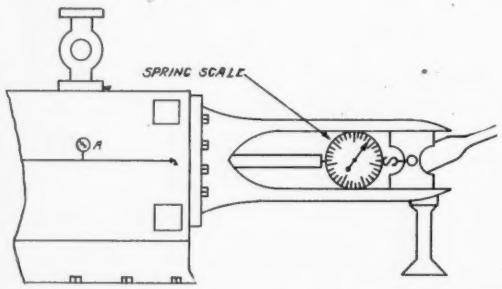


FIG. 3. METHOD OF ATTACHING SPRING SCALES TO DETERMINE PACKING FRICTION

having no cutoff, hence the effect is shown by the increased height of admission line.

I have tried various ways of getting at this friction of packing and the above described method, which I have used on both pumps and engines, will, I believe, appeal to any practical engineer. Others can try this as I have and, I am positive will find the test to result the same as stated above. The critic may say that is an extreme case; but who has not seen rods and stuffing-boxes screwed up so solid that the gland is released with difficulty, and all to save the little job of repacking?

A. C. WALDRON.

College Education and Practice

I HAVE READ the excellent article in the June 1 issue by J. B. Dillon entitled "Education and Then—" with a great deal of interest. I myself am a college student and have taken but a year off for practical experience.

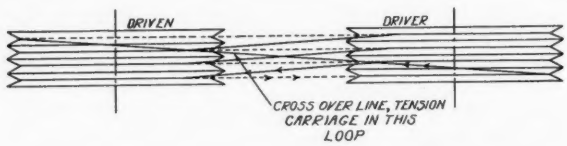
A few days ago, I returned to my Alma Mater to look things over and to see my former classmates. I was no less struck than the writer of the above article at the kind of education these men receive. For example, they could converse fluently about breaking strains on ropes and guys, but it is doubtful whether any one of the entire class could "make up" a piece of stranded guy wire or tie a "catspaw."

The prevailing idea I met was: Give us the tools we want, if you want the work done; and not the American ingenuity that says: We will try to do the work with the available tools. Perhaps, one may say, a college man gets his practical education later on the job. Yet we want "men qualified to take up the task of getting the work done." How can college men go forth without this practical side and still expect to give the order "to brace this joist" or "guy this pole"?

J. B. FICKLEN.

Alinement of Rope Drives

IT IS OFTEN said that lack of alinement is not a matter of much consequence in a rope drive. This is erroneous because of the chafing effect where the rope leaves or enters the grooves at an angle; this may be



ANGULARITY OF ROPE DRIVE DUE TO SHORT CENTERS

the case where the sheaves are not in line or where the shaft centers are too close. The lack of alinement has an evil effect on both continuous and English or separate rope systems, but short centers are not injurious to the English system as far as the chafing is concerned. We have two drives; on one the shaft centers are 17 ft., on the other over 30 ft. This last rope wears much longer than the one with the 17-ft. center. The illustration shows, on an exaggerated scale, the angularity due to short centers.

Rope transmission has one decided advantage; there is little or no slippage. When first installed, we were worried when a strand would come loose because it took a lot of time to make a new splice even if we had the necessary amount of slack in the drive for the splice. We got around this by taking a strand of new rope and removing about three yarns to make its size correspond with the old strands and laying it in place of the defective strand. We have carried this to the extent of relaying all four strands, which gives plenty of time to get

ready to remake the splice or put on a new rope when it will not interfere with operating. We have one splice in service now that had a strand laid in months ago, with a rope drive one can never tell by examination when a strand is going to whip loose.

It is fine to have about four men who know how to splice, then two can run each way from the center of the splice and the job is done in a little while.

J. O. Benefiel.

Too Much Oil in the Reduction Gear Case

The chief engineer of a large textile power plant had occasion to renew the oil both in a 7500-kw. General Electric Co. horizontal turbine and also in the reduction gear case of the Westinghouse turbine driving the Le Blanc condenser belonging to the main turbine. A high grade of turbine oil was used of the same kind as was previously used. About 3 bbl. was put into the reservoir of the main turbine and 1 bbl. into the gear case.

After starting all went well with the main turbine, but the oil in the gear case showed signs of warming up. Steadily through the day, the temperature rose until late in the afternoon the housing was giving off smoke fumes. Samples of the new and old oils were compared, but were found to be the same. What added to the mystery was that the oil in the main turbine was running cool, showing that the oil in itself could not be at fault. Finally, as a last resort, the engineer drew off from the gear case several pailfuls of oil. Almost immediately the temperature of the oil began to fall, and in an hour's time was down to normal. Evidently too much oil had been put in, the level reaching high enough for the large gear to catch it and hurl it against the housing. There is such a thing as too much oil.

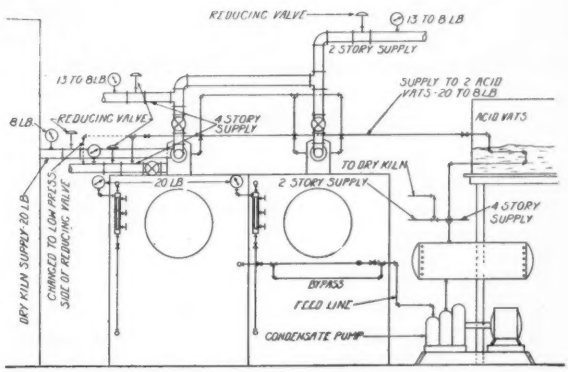
John A. Collins, Jr.

Improvements in Heating System

An industrial plant has two horizontal return tubular boilers for supplying steam to heat two buildings, one dry kiln and two vats for heating acids. The system was installed 10 yr. ago. Up to this winter, it was impossible to heat these buildings or keep up the production in cold weather. The buildings are four stories high with 15,000 sq. ft. of radiation and 20,000 sq. ft. in the dry kiln and the acid vats, in addition to which another building was erected in the past year with 8000 sq. ft. of radiation, all of the indirect gravity system.

As it was impossible to heat the two older buildings, the management and heating engineer decided on purchasing a new boiler. The pressure on the boilers is 20 lb. and the pressure on the buildings was reduced to 13 lb., the steam lines leading to the dry kiln and acid vats led direct from the boilers without any reduction in pressure. When the system from the new building was cut in, the circulation stopped throughout the plant and the radiation was drained at different points to get heat, as this return water was drained to the sewer or outside, the boilers had to be fed with cold water from the city supply, making it necessary to burn an excess of coal.

On looking this system over, it was noticed that the returns came back to the trap when the pressure on the boilers was allowed to drop below 13 lb., showing that there was some part of the system that was carrying a higher pressure than the other. In going over the piping, it showed that the dry kiln and acid vats were receiving boiler pressure and backing up the returns from the three buildings.



STEAM PIPING TO HEATING SYSTEM

After making the changes shown in the accompanying sketch and reducing the pressure on all the different lines, the two boilers are supplying sufficient steam with a reduction in the consumption of fuel.

C. J. Miller.

Operating Alternators in Parallel

When I took charge of the power plant of the Southern Railway & Light Co. about 2 yr. ago, they were using a uniflow engine of 500-hp. to drive a 200-kw. alternator for light and power, and a 500-v. direct current machine for street railway service. These machines were driven by what is called a tandem belt drive.

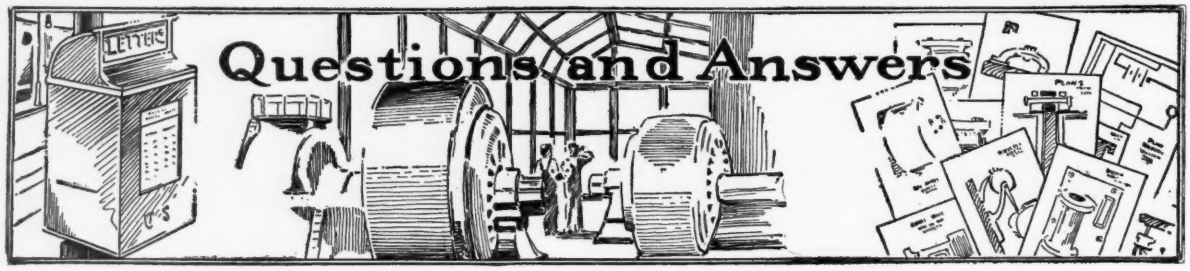
Later the street car service was discontinued, and that left the d.c. machine idle. The alternator was not large enough to load the engine, so we bought a 150-kw. secondhand alternator very cheap and installed it in the place of the d.c. machine.

I was very much in doubt as to whether or not I could run these machines in parallel, and make each machine carry its part of the load; but when figuring for the size of the pulley, I added to the diameter of the engine drive wheel twice the thickness of the under belt, and I am glad to say that these machines are running together, and the load equalizes nicely, also when running in parallel with our other machines.

I have never heard of two machines being run together in this manner. I have talked with several traveling men for large electrical firms and I haven't found one who ever heard of two machines being run in this way.

R. L. Hartsfield.

Opinions have differed as to the fatigue-causing powers of different occupations; and many efforts have been made to establish a scale for definitely ranging them. A recent report of the U. S. Public Health Service states that the amount of sulphur excreted through the kidneys of men engaged in a wide range of work has been found to coincide closely with the relative arduousness of the work, as estimated by four good observers.



Bowed Boiler Stays

CAN YOU tell me what is the cause of a bowed or sagged head-to-head boiler stay? I found this condition existing in one of our boilers when an inspection was made recently. A. C. W.

Grounded System

REFERRING TO trouble H. S. is having with ground detector lamps as stated on page 488 of the May 1 issue, I would suggest that he test his rotary transformers for leakage between primary and secondary winding, also for leakage between the primary winding and the transformer cases.

This appears to me to be the place most likely to cause trouble. W. H. GREENSLIP.

Best Radius of Pipe Bends

IT SEEMS to be the general opinion that the larger the radius of a pipe bend is made, the less friction there will be in the line.

Kent states that there is the minimum friction in a pipe of given length when the bend is 2½ times the diameter of the pipe.

What is your opinion in regard to this matter?

T. H. H.

Gas and Water Separator

WE ARE interested in some kind of a separator or trap to handle gas from an artesian water well. In trapping this gas, we want to use it for fuel. An actual test has not been made of the amount of gas and water discharged from this well, but I should judge that there is at least 30 per cent gas out of the flow from a 4 in. pipe working under about 60 lb. pressure. How can we accomplish this result? R. T. S.

Piston Valve Engine Problem

AFTER CONSIDERING E. C. W.'s sketch of his piston valve which appeared on page 485 of the May 1 issue of Power Plant Engineering, we find that the maximum exhaust port opening on the head is ⅜ in., while on the crank end, the valve overtravels the port 13/16 in. There is a ¾-in. overtravel on the head end steam port, while on the crank end, the port opens only 5/16 in. To remedy this condition so that the port openings will be the same on both ends, the valve rod should be shortened 17/32 in. Blocking both piston and valve so that they will not move, the eccentric should be loosened on the shaft and the valve rod taken up this 17/32 in. after which the eccentric should be clamped in the new position. Both head and crank end exhaust laps are 7/16 in. and the steam laps are each ½ in.

This engine was designed to run at 340 r.p.m.

Is There Any Trouble?

ON PAGE 585 of the issue for June 1, Operator wants to know what the trouble is with his plant; but I wish to ask whether there is any real trouble. If the boilers are simply overloaded, that solves the problem.

If the original diagrams were available, the power developed could be calculated; but diagrams seldom or never are reproduced exactly the same size as the original, hence it is not possible to use those that are shown.

An estimate of what might be the conditions is submitted as follows: With the equipment that he mentions, and the coal described, it will require about 10 lb. of coal per kilowatt-hour. If the generator is used to its full capacity of 250 kw., it will use 2500 lb. of coal per hour, or 1250 lb. for each of two boilers. If the grates are 6 by 7 ft., each one has 42 sq. ft. of grate surface, or its equivalent in case of an underfeed stoker. This means a consumption of 30 lb. of coal per hour per square foot of grate surface, and if this assumption is correct it explains the difficulty in keeping up steam with two boilers in service, as this is a high rate of combustion, and you will always have more or less trouble in maintaining it. W. H. WAKEMAN.

Boiler Seams; Leaky Pistons; Valve Installation

ANSWERING THE questions on page 485 of the May 1 issue of Power Plant Engineering:

1. Butt constructed seams might be used on the furnace plates of a marine type or round furnace if they are placed below the grate line, otherwise not. Most inspection laws will not, however, allow this construction. On straight side fireboxes, of the locomotive type, such a joint should not be used.

2. To test a pump piston or inside packed plunger, for leakage, block the piston near the back end and remove the suction valves on both head and rod ends, and if necessary, the discharge valves. Apply hydrostatic pressure behind the piston and watch for any leakage that might come through the head end valves. Do not stand in front of open cylinder.

3. All globe valves in a boiler feed line should be so installed that the delivery is from under the seat. With this arrangement, the boiler can get water even if the valve disc should come off and drop on its seat.

R. G. SUMMERS.

Accumulator Weight

I HAVE a hydraulic accumulator the plunger of which is 5 7/16 in. in diameter. I would like to know how much weight I would have to put on this accumulator to get 2000 lb. gage pressure. T. D.

A. In order to obtain a pressure of 2000 lb. per sq. in. gage with an accumulator having a plunger 5 7/16 in. in diameter, it is simply necessary to find the total force on this plunger. With a diameter of 5 7/16 in., the area is 4.27 in. and the total force is then 2000 × 4.27 = 8540 lb. This would then be the weight that would have to be put on the accumulator.

Flywheel Design

IS IT SAFE to run a flywheel faster than 6000 ft. per min., rim speed? J. C.

A. For the ordinary cast-iron flywheel, 100 feet per sec. or 6000 ft. per min. is usually considered to be the maximum allowable speed; however, special wheels for special purposes have been made to run at 15,000 ft. per min. A wheel designed for this speed consists of a cast-iron hub to which two steel disks, 20 ft. in diameter are bolted. Around the circumference of this wheel are wound 70 tons of steel wire under an initial tension of 50 lb. This wheel made 240 r.p.m. which corresponds to a rim speed of 15,080 ft. per min.

Rotary Steam Engines

JUST WHAT is a rotary steam engine? Does it work upon the principle of steam expansion or not? In Hawkins' "New Catechism of Steam Engines" it states that "this engine does not work upon the principle of steam expansion," while a well-known authority in the Massachusetts Department of Education states that "the means of power in this engine is the pressure due to the expansion of steam." W. D. M.

A. It is our opinion that rotary steam engines do utilize to some extent the expansive power in steam. There are, of course, several varieties of these engines which use in various degrees this power in the steam. These engines have not proved to be of any commercial success so far.

Design of a Solenoid

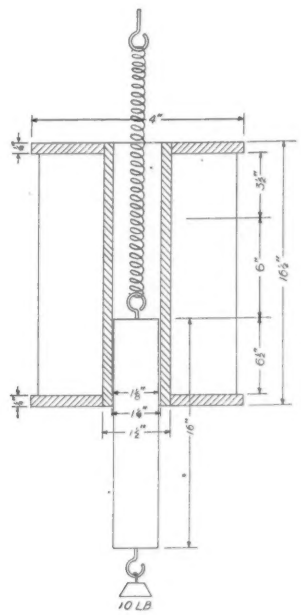
I WOULD like to make a plunger or solenoid magnet that will pull or lift 10 lb. up 6 in. I wish to get information as to how this magnet may be made; size of wire, number of turns and length. W. M.

A. On micarta or brass tube 1¼ in. by 1½ in. by 16½ in. long, place two end washers 4 in. diameter of ¼-in. micarta. Wind 8840 turns of No. 19 B. & S. gage D.C.C.C. wire. Supply lamp cord leads and use soft iron plunger 1⅛ in. diameter by 16 in. long. Use spring to offset weight of plunger.

There are many complicated formulas for figuring out the pull of solenoids, but even in the best of conditions, there are so many variables, especially in the permeability of the iron, that the final results may vary 10 or 15 per cent from the original calculation. The following will serve to illustrate the steps necessary in designing a 110-v. d.c. open solenoid to lift 10 lb. a distance of 6 in. with an intermittent rating. Practice has shown that the maximum pull is obtained when the plunger has entered the solenoid about 0.4 of its length. This pull prevails for another 0.4 of its length, gradually dropping off in the last 0.2 to zero when the magnetic centers coincide.

If the travel or range is 6 in., and this is 0.4 of the solenoid length, then the total length must be 15 in. We will figure 16 in. for a little leeway. With this length, a plunger 1⅛ in. in diameter with a cross section of one square inch will be consistent.

The formula for pull in pounds is $P = KAIT \div l$ in which P = pounds pull, K = a constant (about 0.0095 in this case), A = area in sq. in. cross section of plunger, IT = ampere turns, l = length in inches.



SOLENOID DESIGNED TO LIFT WEIGHT OF 10 LB. A DISTANCE OF 6 IN., INTERMITTENT SERVICE

Transposing the formula, we get

$IT = (l \times P) \div KA = (16 \times 10) \div (0.0095 \times 1)$ — 17,000 amp. turns.

General practice has shown that a solenoid with a diameter of one-quarter its length gives consistent results; so referring to the sketch, we find available a winding space of 16 in. by 1¼ in., or a total of 20 sq. in. cross section.

There are many complicated formulas for determining the size of wire and these are excellent when one has many solenoids to design. The writer often finds it convenient to take a likely size of wire and work the calculation backwards. For instance, in our present case, let us assume a No. 19 double cotton covered copper wire. A wire table says we can get 340 turns per layer in a 16-in. space and about 26 layers in a 1¼-in. space with thin insulation between layers. This gives a total of 8840 turns.

From the sketch, the mean diameter of the winding is 2¾ in., so the length of a mean turn is 8.63 in. The length of 8840 turns is then 76,289 in., or 6357 ft.

A wire table says that No. 19 copper wire has a resistance of 8 ohms per 1000 ft., so the total resistance of the coil must be about 50 ohms. From Ohm's Law, the current at 110 v. will be 2.2 amp. The ampere turns will be $8840 \times 2.2 = 19{,}448$ amp. turns, which quite closely meets our calculation.

In the same manner, it will be found that No. 18 will develop 22,800 amp. turns and No. 20 will develop about 15,000 amp. turns.

For continuous duty, a coil can radiate only about 0.5 to 0.7 w. per sq. in. of outside surface and keep within a reasonable temperature rise; but for intermittent duty, this value may go up to 10 or 12 w. per sq. in. depending, of course, on the length of time that the coil is energized. In the present case, the watts developed are 2.2×110, or 242, and the outside surface (neglecting the ends) is about 200 sq. in. Therefore our coil will radiate about 1.2 w. per sq. in., which it should do without difficulty. V. H. Todd.

Motor Service

If the input to a transformer is 500 w., what would be the output, ignoring losses?

2. Which motor is the better for general use, the squirrel cage or the wound armature motor? J. M.

Answers

If a transformer such as referred to in your letter has an input of 500 w. and all losses are to be ignored, then the output also will be 500 w. This condition is, of course, not obtainable either in practice or in theory, as under such conditions the efficiency of the unit would be 100 per cent, a practical impossibility.

2. For general use and where only constant speed is required, a squirrel cage motor would be better than a wound rotor motor. Wound rotor motors are primarily for use in connections where variable speeds are desired to be employed.

Lap Riveted Joint Efficiency

What is the pitch of rivets for a double riveted lap joint that will have an efficiency of 75 per cent where the diameter of the rivet holes is 13/16 in. and the thickness of plate 3/8 in.? M. B.

A. It is problematical whether or not a joint having the dimensions specified can have an efficiency of 75 per cent, hence we will solve for the pitch that will give the maximum efficiency.

Efficiency in tension $Et = (p - d) \div p$, efficiency in shear $Es = (2 \times 3.14\ d^2 \times Us) \div (4 \times p \times t \times Ut)$ and efficiency in compression $Ec = (2\ d \times Uc) \div (p \times Ut)$.

We will assume for use in these equations Us, ultimate shearing strength = 40,000 lb.; Uc, ultimate compression strength = 95,000 lb.; Ut, ultimate tensile strength = 55,000 lb.

By evaluating and comparing Es, and Ec : Es = $(2 \times 3.14 \times 0.66 \times 40{,}000) \div (4p \times 0.375 \times 55{,}000) = 2.008 \div p$, $Ec = (2 \times 0.812 \times 95{,}000) \div (p \times 55{,}000) = 2.805 \div p$, it will be seen that the efficiency in compression is always greater than that in shear so that it need not be considered. The value of p which will give the maximum efficiency obtainable will then be found by equating the expressions for efficiency in tension and shear. $Et = Es$ or $(p - 0.812) \div p = 2.008 \div p$, $p - 0.812 = 2.008$ or $p = 2.820$ in. The joint efficiency is, then, $(2.820 - 0.812) \div 2.82 = 71.20$ per cent.

Strength of Bolts

Which of the following types of bolts is considered to be the strongest: U. S. standard, S. A. E., or Metric system?

A. The strength of a threaded bolt depends upon the net cross-sectional area at the base of the threads. The thread form for either the United States standard, the Metric system or the A. L. A. M. or S. A. E. standard is the same and consequently the net sectional area is dependent upon the number of threads per inch.

The standard U. S. 3/8-in. bolt has 16 threads per inch and the net sectional area is 0.068 sq. in. The ratio of net area to the area of the body of the bolt in this case is 61.8 per cent. In the Metric system, a 10-mm. bolt has 16.9 threads per inch. The net area is 51 sq. mm. and the body area is 78.54, so that the percentage of the area at the base of the threads is 65 per cent. A 3/8-in. S. A. E. standard bolt has 24 threads per inch and the net area is 0.085 sq. in. and the percentage is 72.2 per cent.

It will be seen from these figures that the S. A. E. standard has the largest net section for a given body area and would therefore be the strongest.

Air Required for Combustion

Assuming that 1⅔ times the theoretical quantity of air is used to burn a given quantity of fuel, how many cubic feet of air would be required to burn 100 lb. of coal having the following composition: hydrogen, 6 per cent; carbon, 88 per cent; oxygen, 3 per cent; and ash, 3 per cent? H. R. M.

A. Coal having the composition, hydrogen, 6 per cent; oxygen, 3 per cent; ash, 3 per cent; and carbon, 88 per cent, will require air as follows, assuming that 66 per cent excess is used:

The oxygen in the coal will support the combustion of a portion of the hydrogen. We know that these two elements combine in the proportion, $2H_2 + O_2 = 2H_2O$, or by weight, 4 parts H_2 + 32 parts O_2 give 36 parts H_2O. As we have 0.03 lb. O_2, the combining weight of H_2 is $0.03 \div 32 \times 4 = 0.003{,}75$ lb. There then remains $0.06 - 0.003{,}75 = 0.056{,}25$ lb. of hydrogen to be burned in air. From the above weight equation, $O_2 = 0.056{,}25 \div 4 \times 32 = 0.45$ lb.

Carbon combines with oxygen in the proportion $C + O_2 = CO_2$ or by weight 12 parts of C + 32 parts O_2 = 44 parts CO_2. As we have 0.88 lb. of carbon to be burned, the combining weight of oxygen is $O_2 = 0.88 \div 12 \times 32 = 2.345$ lb.

The total oxygen required is then $0.45 + 2.345 = 2.795$ lb. As air is 23 per cent oxygen the weight of air necessary is $2.795 \div 0.23 = 12.6$ lb. With 66 per cent excess, this would become $12.6 \times 1.66 = 20.9$ lb.

As there are, at standard conditions, 12.39 cu. ft. of air in a pound, the volume of air required for the combustion of 1 lb. of coal is $20.9 \times 12.39 = 259$ cu. ft. The requirements for 100 lb. coal would then obviously be 25,900 cu. ft.

Back Pressure in Dry Kiln

WE HAVE an 80-hp. boiler and a 40-hp. engine pulling line shaft, practically loaded. We want to know if we can transmit our exhaust a distance of 80 ft. from the engine to the dry kiln without causing back pressure or loss of power. If so, can we continue our 4-in. exhaust pipe to the kiln and reduce it to 1¼-in. pipe?

C. J. F.

A. There should not be any difficulty in transmitting the exhaust from your engine through 80 ft. of 4 in. pipe. This would result in a drop in pressure of only some one pound or less. If you branch this off into 1¼-in. pipe at the end you should have at least 22 1¼-in. pipes in parallel to avoid causing back pressure on the engine.

Steam Line Installation; Leaky Pump

1. WHAT REQUIREMENTS should be considered in installing a steam line between a boiler and an engine?

2. How can a test be made for a leaky pump plunger or piston?

C. C. R.

ANSWERS

IN RUNNING a steam line from a boiler to an engine, the pitch should be toward the engine. This is to prevent, as far as possible, the water in the line from draining back against the flow of steam, where it is liable to accumulate and be blown into the engine in a slug, which would have disastrous effects. There should be as few bends as possible and those that are necessary should have long sweeps. The line should be well insulated to minimize condensation and provision should be made to take care of expansion.

2. The task of determining leakage past the piston in a water pump is by no means an easy one. One of the best methods is to remove one of the cylinder heads or vent it in some way to the atmosphere, then block the piston in any position and admit water pressure under a full discharge head in the closed end of the cylinder. If there is a leakage past the piston, water will accumulate in the open end and will drain off where it can be recovered and measured.

Miscellaneous Electrical Questions

1. WHAT IS the resistance of a lamp using one ampere at 110 v.?

A. According to Ohm's law, $R = E \div I$, therefore the resistance of the lamp is equal to 110 divided by one, or 110 ohms.

2. How many kilowatts of current are used by an electrical device in 10 hr., rated at 6 amp. at 120 v.?

A. The kilowatt rating is equal to $(6 \times 120) \div 1000$, or 0.720, but the kilowatt-hours for a period of 10 hr. is equal to 0.72 times 10, or 7.2 kw.-hr.

3. What is the reason for installing an oil switch on small horsepower motors?

A. To minimize what arcing may occur upon opening of the circuit either manually or automatically in the case of a switch which acts also as a circuit breaker.

4. Why is porcelain required in basements and bathrooms?

A. Porcelain is required in basement and bathroom wiring because of the attendant dampness and moisture.

5. How many watts in one horsepower?

A. One electrical horsepower is equivalent to the expenditure of 746 w. of energy.

6. What are the taps in a motor starting compensator for?

A. Motor starting compensators are equipped with taps in order to provide a variable range of starting voltages.

7. What damage would result to a three-phase motor if left running single-phase?

A. The working circuit would become overloaded and liable to burn out.

8. What damage would result if the neutral fuse should blow on an unbalanced single-phase, 220-v. three-wire circuit?

A. The current-consuming devices on the "light-load" side are apt to receive an excess of current and as a consequence either burn out or at least be damaged.

9. In concealed work when hanging from knob and tube to conduit work, what fittings should be used?

A. A combination conduit terminal fixture fitted with a porcelain outlet cover through holes in which the emerging leads may be made to pass.

10. What is the protection required for heating devices above 660 w.?

A. Every heater of more than 6 amp. or 66 w. capacity should be protected by a cut-out.

11. How may the rotation of a direct current motor be increased?

A. Direction of rotation of a direct current motor may be changed by reversing either the armature or the shunt field connections.

12. How may a three-phase alternating current motor be reversed?

A. Direction of rotation of a three-phase alternating current motor may be reversed by interchanging any two of the supply leads.

13. When wiring an ice house, refrigerating plant or brewery, what materials should be used?

A. In ice houses, breweries and other damp places, rubber covered wire should be used and rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least 1 in. from the surface wired over and should be kept apart at least 2½ in. for voltages up to 300 and 4 in. for higher voltages.

14. What kind of wire should be used in an underground service conduit?

A. Wires in underground conduit must be lead covered.

15. How can you determine the plus and minus of a direct current circuit?

A. Polarity may be tested by dipping the wires connected to both leads of the circuit into a glass containing a solution of salt in water. The wires must be held about 1 in. apart. Bubbles of gas will be given off in greater quantity from the negative pole.

Correction Note

IN OUR June 1 issue on page 587, under the head, Engineers' Examination Questions, the answer to question 35 states that the safe maximum speed of a cast iron flywheel is 100 ft. per minute. This should, of course, read 100 ft. per second.

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Responsibility for Waste

As one of the most wasteful users of our natural fuel supply, the steam power plant industry will do well to follow up the reports now being made public by the American Engineering Council's committee on elimination of waste in industry. While this committee has not investigated power plants as an individual industry it suggests to one reading the first report, which was issued June 3, that if responsibility for certain wastes be placed upon departments or individuals these wastes may be reduced to the point where they are unavoidable. In this report, the committee divides the responsibility between management and labor and, contrary to the opinions of many, it was estimated that "over 50 per cent of the responsibility for these wastes can be placed at the door of management and less than 25 per cent at the door of labor."

In the power plant, it is quite likely that, if a fair analysis were made, a similar proportion would be found to exist and it is quite logical to suspect that the cause could be traced to the various methods and means for checking the work of those who have the actual handling of machinery in the plant, while the management many times is a law unto itself and makes little or no effort to find its own shortcomings.

In the boiler room, for example, the average efficiency the country over probably does not exceed 60 per cent, yet we know of many plants where 75 to 80 per cent is standard practice the year around. Can the entire responsibility for this low efficiency be placed upon those who have charge of boiler room equipment? Decidedly not, neither can the operatives shirk all responsibility because the equipment may not be the most efficient obtainable.

It is unquestionably the duty of operatives so to maintain, adjust and operate equipment under their care as to secure the highest efficiency possible under the given conditions which they cannot change for the better. Likewise it is the duty of the management to provide equipment for the plant which will give the highest economy when operated under the conditions for which the management has had the plant designed, and further to arrange load conditions as nearly ideal as possible under the existing industrial conditions.

In the power plants throughout the country there is too much divided responsibility. With each individual given specific duties and held responsible for maintaining or bettering well established standards we can reasonably expect a marked decrease in the existing wastes in power plants generally.

Types of Engineers Needed

During the month of June the technical schools of the country have released for industrial work many hundreds of graduate engineers, each seeking a career that will bring to him a noteworthy reputation in his chosen line of endeavor. Although just at present the country may seem over supplied with engineers, there is, nevertheless, a great need for these young men full of ambition and determination to discover new methods and means for utilizing nature's forces and materials for the betterment of mankind.

The success that these men will achieve will depend largely upon the type of engineering which they select

and their qualifications to fill the need in that field. First of all the industries of the country need scientists to delve deeper into natural laws governing the qualities and characteristics of materials under the various conditions met with in industry.

Next in line are those who are capable of taking laboratory processes and adapting them on a commercial basis to industrial conditions.

This done, the human side of engineering enters and the man versed in the science of industrial relation is called upon for his contribution to the industry. In this work the engineer deals not only with the employes, but also with the employers; in many cases he would be the arbiter between contending factors in the industry. To him is presented the difficult problem of keeping those associated with his concern happy in their work and the need for such men is paramount today. Such a task belongs rightfully to a trained engineer with a judicial type of mind capable of dealing justly and humanly with his associates.

Another type of engineer sorely needed by the whole country today is one with exceptional sales ability. The country's natural resources are being deplorably wasted; wasted not because engineers of the country do not know better ways of utilizing them, but because these methods have not been put into general practice. To establish economical block plants in cities, develop hydraulic power sites, promote mine-month power plants, commercialize combined by-product coke and power plants, establish super-power zones, require the highest type of engineering knowledge combined with a sales ability capable of dealing with the most influential financiers of the country.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Off Duty

One of the most puzzling facts that has ever occupied the human mind is the relation existing between the diameter and the circumference of a circle.

In school, as children, when we were first initiated into the rudiments of geometry, we were told that this relation was 22/7 or 3 1/7. That is, a certain diameter would fit into a circle constructed upon that diameter just 3 1/7 times. At that time, for our purposes and for our as yet undeveloped minds, this value sufficed. It was not exact, however, and as we grew older we became familiar with the more accurate value, 3.1416, which, we learned, was termed Pi, after the Greek initial letter of the word periphery. Pi! At that time the term amused us. Thoughts of it were associated with visions of marvelous examples of culinary art filled with luscious huckleberries.

As time went on, however, we found that even the value 3.1416 does not express the true relation. What, then, is the exact relation? Many minds before us have asked this question without avail. Today, after two and one-half thousand years, during which time both competent and incompetent minds have striven in vain to obtain an absolute numerical value expressing the relation, the world knows that it cannot be expressed by any whole or by any combination of whole and fractional numbers. It is incommensurable.

The number has, however, been carried out to a great number of decimal places. In 1873 Shanks carried an approximation out to 707 decimal places. While this has neither practical nor theoretical value, it serves to illustrate the excellence of modern methods of arriving at the value of Pi. The methods of calculating its value are varied and while the number is generally thought of in its relation to the circle, it is interlinked with many other natural phenomena.

For instance: Suppose the floor of a room is divided up into equal squares so as to resemble a huge chess board, and a needle exactly equal in length to the side of each of these squares is cast haphazard upon the floor. If we calculate, now, the probabilities of the needle so falling as to be wholly within one of the squares, that is, so that it does not cross any of the parallel lines forming the squares, the result of the calculation for this probability will be found to be exactly equal to Pi—3. As a matter of fact, Prof. Wolff, after 10,000 trials, obtained the value of Pi correct to three decimal places.

Strange, isn't it? To think that such an absurd procedure should give us the value expressing the relation between the circumference and the diameter of a circle! Strange, indeed, but not preposterous. The keen student of nature is accustomed to such amazing truths.

Therein lies the value of science—in establishing such relations. It is the object of engineering to apply them. Sometimes they prove of immense value. Take as an example, the matter of long range weather forecasting. This is well known to be dependent upon meteorology, oceanography and astronomy and it has been very conclusively proved that the amount of rainfall is affected by sunspots and the amount of the sun's radiation received by the earth.

Lately, however, while conducting a continuous investigation of oceanic phenomena at Scripps Institution pier in Southern California, there has been observed a very definite relation between the ocean temperature in summer and the amount of rain falling during the following winter months. This relation is entirely too exact to be a coincidence and continued investigations are under way. This series of observations began in 1916 and, up to the present time, indicates that the lower the summer temperature of the ocean, the higher will be the rainfall in Southern California during the winter months or raining season. Complicated as this seems, it is entirely probable that in the near future, by accurately recording ocean temperatures during one time interval, we shall be able to predict with absolute certainty the amount of precipitation during a succeeding time interval. The value of such predictions to agriculturalists and to hydroelectric plant operation is too apparent to even warrant discussion.

Eliminating Gas in Fuel Oil Tanks

By Charles W. Geiger

A NOVEL method has been employed in eliminating the formation of gas in fuel oil tanks of the fire boats in use along the San Francisco water front. This is accomplished by keeping the fuel oil tanks full at all times, so that there will be no space in the tank for gas to form, thereby eliminating the possibility of an explosion.

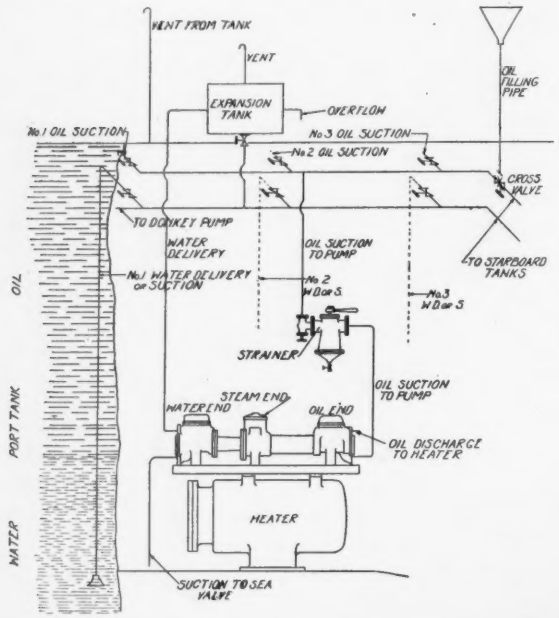


FIG. 1. COMBINED OIL AND WATER PUMP CONNECTIONS

The pump illustrated is of special construction and is provided with steam cylinder in the center, oil cylinder at the end to the right, and water cylinder at the end to the left. As fuel oil is pumped from the top of the tank shown to the left in Fig. 1, the water is pumped into the expansion tank, and by its own weight

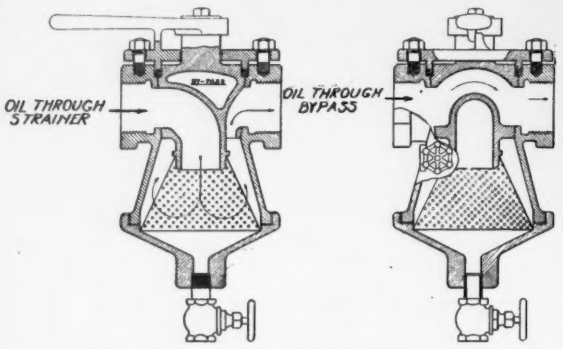


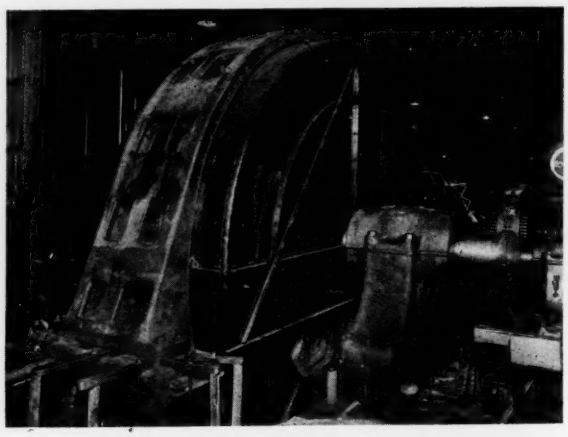
FIG. 2. SECTIONAL VIEW OF STRAINER

runs into the bottom of the fuel oil tank and displaces the oil so that the tank is always full as shown.

Another interesting feature is a device installed above the pumps and marked strainer in Fig. 1. This device is so arranged that the strainer can be cleaned while the plant is running. The drawing to the left in Fig. 2 shows how the strainer normally operates. The oil as shown by the arrows, passes to the center, down the central tube and is strained by passing through the perforated cone. The clean oil passes up to the exit, while the dirt settles at the bottom of the strainer. The drawing shown in the cut to the right shows how the oil may be bypassed around the perforated cone, so that the cone may be cleaned of the dirt that has accumulated in it. By opening the bypass valve, oil flows directly through the line as shown by the arrows. Then by opening the valve at the bottom of the strainer, the dirt can be forced out with the steam, which is supplied by opening the small valve at the side of the strainer. This has many advantages. It can be operated and cleaned without soiling the hands. The flow or pressure of the oil is not changed while cleaning. If a leak in the suction line causes difficulty in the operation of the pump, it can be readily located by closing the suction valve at the pump and opening the steam valve on the strainer. In this line, steam is forced into the suction line and the leak will be indicated by the issuing steam. Heavy oil can also be heated in this manner when there is difficulty in starting the oil pump on a cold morning.

Large Horizontal Waterwheel Driven Generator

WHAT is said to be the largest horizontal waterwheel driven generator ever built has recently been completed. The machine is one of two being built for the Great Western Power Company of California, and will be installed in the Great Meadow plant



22,222-KV.A. HORIZONTAL WATERWHEEL DRIVEN GENERATOR

on Feather River. It is a three-phase, 60-cycle machine, rated 22,222 kv.a., 90 per cent power factor, 11,000 v., 171 r.p.m.

The fact that it was built to operate on a 165,000-v. transmission line, the highest operating voltage to be reached so far in this country, caused some interesting features to be incorporated in its construction. It was designed with special reference to line charging requirements so that with full-load armature current, the transmission line voltage will not build up to over 80 per cent of the normal voltage. Silicon steel was used

in the construction of the armature, to minimize core loss. Tests made at the factory on the generator show that it has 97.25 per cent efficiency at full load, and unusually high efficiency at partial loads. These are 95 per cent at half load, and 93 per cent at quarter load. All efficiencies were at 90 per cent power factor.

The rotor consists of four separate wheels made into a single spider, with rim dovetailed to receive the poles. The machine is enclosed for ventilation, having air inlets on each side, consisting of ducts coming from underneath. The heated air is expelled into the room. Some of the dimensions are as follows: Total height over all, 21 ft.; distance over the end shields about 7 ft.; distance from the floor line to the top of the machine, 13 ft. The total net weight is 334,000 lb.

The illustration shows the machine as set up for testing at the factory. The intake ventilation ducts are not assembled, but the openings can be seen under the bearing. The projection of the armature shaft is for the application of the waterwheel, of which there are two, one on each end of the shaft.

Synchronous Condenser Automatically Operated

A SYNCHRONOUS condenser that has two special claims to interest is at present operating at the Hazel Green, Wis., station of the Interstate Light and Heat Co. of Illinois. It is the first synchronous condenser whose entire operation, starting, stopping and regulation is entirely automatic, and it has been operating successfully and continuously for 4 yr.

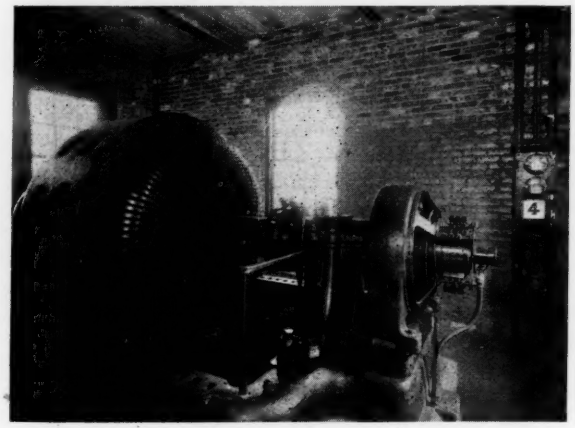


FIG. 1. SYNCHRONOUS CONDENSER, HAZEL GREEN STATION

According to recent reports received from the plant its effect on the power factor, and consequently on the fuel consumption at the main plant is distinctly noticeable. Once when it was shut down for inspection, the firemen at the power plant complained about being forced to shovel so much more coal. They said that if the condenser remained off the line for any length of time it would be necessary to add another man to the boiler force.

The condenser is a 300-kv.a. synchronous unit rated 2300/4000 v., and was placed on the lines to correct the power factor by maintaining constant voltage. The station where it is located is in a mountainous and more or less inaccessible country, where trained operators are hard to get. As a matter of fact, most of the personnel are quite unfamiliar with the operation of electrical apparatus. This makes the successful operation of the condenser for such a long period even more notable.

Automatic condensers have a wide range of application. They may be installed anywhere on a system to

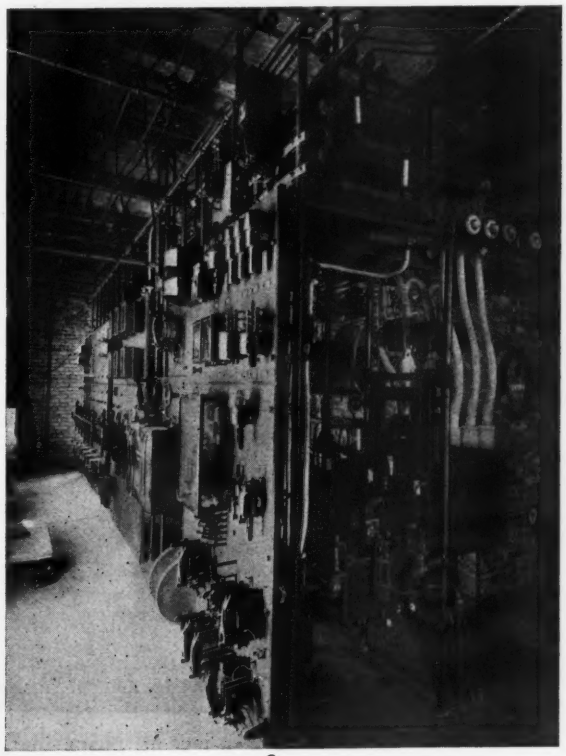


FIG. 2. SWITCHBOARD AT HAZEL GREEN STATION

compensate for the wattless component of a low power factor load, and maintain practically constant voltage. This automatic control makes them free from such considerations as accessibility of location, and the simplicity of the control system does not require a force of trained operators to insure its correct performance. Even the men to be found on a small system are able to keep it in good operating condition.

Welding the Base of a 250-Ton Hydraulic Press

A TYPICAL INSTANCE of the practical application of oxy-acetylene welding in repair and maintenance of plant equipment is illustrated in the accompanying cut, which shows operators welding the base of a 250-ton hydraulic press that was badly broken in service.

The heavy base was broken entirely through, the fracture extending diagonally across the center. To bring the parts together properly for welding, it was necessary to bind them with a chain and supplement this with a steel plate securely bolted to the uprights.

The necessary chamfering was done to secure penetration and proper bonding throughout the joint, and an improvised preheating furnace was then built up of "I" beams and loose brick. Approximately 126 lb. of charcoal and 200 lb. of asbestos paper for covering were used.

When the base was brought to proper heat, openings were made in the asbestos sheeting to afford access to the work in operating the torches and filling rods, and

VIEW SHOWING IMPROVED FURNACE IN PLACE

the actual welding was begun. After the work had progressed to a point where the girding interfered with the operators, the chain was removed, the steel plate being then sufficient to keep the parts properly alined. There were 44 in. of linear welds (4½ in. deep) besides an area of 8 by 4½ in. that was missing and had to be built up. After welding, the entire base was allowed to cool slowly in the furnace.

The job was handled by two operators and approximately 250 lb. of cast-iron alloy rods were used in filling.

Illinois State N. A. S. E Convention

THE ANNUAL Illinois state convention of the National Association of Stationary Engineers was held in Chicago at the Municipal pier June 8, 9 and 10. Delegates from the twelve state sub-organizations were present in force. The convention was of a business and social nature, no technical papers being given. The educational part of the program consisted in exhibits of some 240 members of the Central States Exhibitors' Association. Practically the whole field of power plant equipment, from boilers to gaskets, was covered in the displays.

The attendance as reported by the president was excellent. In the evening of June 9 it was estimated that 9000 persons were present.

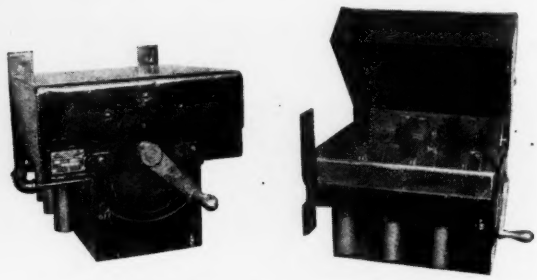
On June 10 the following officers were installed: president, Fred Gielow; vice-president, A. C. Grantz; secretary-treasurer, Stanley H. Raven; and state deputy, M. E. Harris.

Except for the office of the secretary-treasurer, which was filled last year by Theodore W. Lietz, these officers are the same as for the year 1920-1921. Chicago was chosen as the convention city for next season's meeting and it is expected that it will again be held on the pier.

New Fused Entrance Switch

THE accompanying photographs show a new fused extrance switch which has recently made its appearance on the market. This switch is rated at 100 amp., and 2500 v., and is made in two and three poles single throw. These switches are principally used by distributing companies at the end of their 2500-v. distributing lines, and at the entrance of the line to the customers' plant.

This switch is a maximum in safety first features. All live parts are completely inclosed in pressed steel case and tank. The leads go in through fiber bushings, and the cover is interlocked so that it cannot be opened when the switch is closed. The fuses are entirely cut off from the line when the switch is open.



TWO VIEWS OF FUSED ENTRANCE SWITCH

The switch is primarily an oil immersed knife switch with fuses mounted in the top. The contacts are a special self-alining knife blade type. The moving contacts are carried on a wooden drum. The fuse clips which are also self-alining are mounted on a heavy wooden base, and are designed to take standard fuses.

The switch has a large application on high voltage distribution where safety first features not contained in the ordinary knife switch are desired.

News Notes

IN A recent issue of the Deane News, published by the Deane Works at Holyoke, Mass., of the Worthington Pump and Machinery Corporation, is described the delightful celebration of the fortieth anniversary of the connection with the works of Charles L. Newcomb, manager. Several addresses of congratulation were made, and floral tokens of esteem were received by Mr. Newcomb from the employes and from engineering societies of which he is an honored member. A great number of

telegrams of congratulation were received from friends, officials of the Worthington Corporation and officers of the A. S. M. E., giving evidence of the high esteem in which Mr. Newcomb is held by his associates and fellow engineers, and of the enviable record that he has made.

THE ANNUAL MEETING of the stockholders of the Westinghouse Electric & Manufacturing Co. was held in the executive offices of the company at East Pittsburgh, June 8. At this meeting four directors were re-elected for a term of four years: James D. Callery, chairman of the board, Philadelphia Co. of Pittsburgh; Paul D. Cravath, Henderson, Leffingwell & de Gersdorff, of New York City; Harrison Nesbit, president of the Bank of Pittsburgh, N. A. In addition to these one new member, William H. Woodin, president of the American Car & Foundry Co., of New York City, was elected.

Mr. Woodin had previously filled the unexpired term of George W. Davidson, who recently resigned.

ELLIOTT CO., Jeannette, Pa., announces the following additions to its sales organization: R. H. Schmidt goes to the St. Louis district office; W. E. Widau to the Cleveland district office; and R. S. Bellman to the Philadelphia district office. All of these gentlemen have completed a year's course of intensive study and experience with the company's products, immediately following their graduation from engineering colleges. In addition to Elliott Company products, they will also handle those of the Lagonda Mfg. Co., Springfield, Ohio, and Liberty Mfg. Co., Pittsburgh, Pa.

MILTON SNELLING of Washington, D. C., president of the International Union of Steam and Operating Engineers, who was in Denver to attend the forty-first annual convention of the American Federation of Labor, died at the Standard Hotel during the night of June 7, apoplexy given as the cause. On the preceding day Mr. Snelling had complained that he did not feel well and had lain down for awhile in his room during the afternoon. Mr. Snelling was 52 yr. of age, an executive board member of the National Building Trades Union, and at one time was a member of an American Federation of Labor committee which appeared before the national Congress at Washington, besides holding the general presidency of the engineers. He was elected to the last-named position in 1916, before which he was affiliated with his union for ten years. Mr. Snelling also had served as president and treasurer of the Washington Central Labor Union. A widow and 19-yr.-old son survive him.

Book Reviews

SINCE October, 1918, an investigation of warm-air furnaces and heating systems has been carried on by the Engineering Experiment Station of the University of Illinois in co-operation with the National Warm-Air Heating and Ventilating Association. The principal objects of the investigation are, briefly, to determine methods of increasing the efficiency and capacity of warm-air furnace heating systems, and also to establish satisfactory and simple codes for testing and rating furnaces, so that the heating equipment may be properly proportioned for the work it has to do.

Bulletin 120 is the second report of progress in connection with this investigation, and copies may be had without charge by addressing the Engineering Experiment Station, Urbana, Ill.

ELEMENTS OF FUEL OIL AND STEAM ENGINEERING by Robert Sibley and C. H. Delany; 2nd edition, 466 pages, illustrated, 6 by 9, cloth, New York, 1921.

The underlying theme of this book is a study of fuel oil power plant operation and the use of evaporative tests in increasing the efficiency of oil fired plants. The subject matter is treated in three main subdivisions: First, an exposition of the elementary laws of steam engineering; second, the processes involved in the utilization of fuel oil in the modern power plant; and third, the testing of oil fired boilers.

In considering the fundamental laws the point of view is that of oil firing rather than coal firing. In the second division the fundamentals of furnace operation and the design of boilers, furnaces and burners, are treated. The last division sets forth methods to be employed in testing boilers for evaporation and making the heat balance. Miscellaneous tests are given.

ELECTRICAL MACHINERY, by F. A. Annett; 431 pages, 491 illustrations, first edition. New York, 1921.

This is essentially a book for the practical man and the student of electricity. The material has been prepared with an effort to guide the student over many of the pitfalls ordinarily encountered in the study of electricity. All the problems given deal with things that the practical man comes in contact with in his daily work, so as to show how theory fits into practice.

The theory of electricity is explained with the aid of only the simplest mathematics while numerous analogies with sound, light and heat enable the reader to obtain clear conceptions of electrical principles.

The first six chapters of the book deal entirely with the simple theory of electricity and magnetism. These are followed by chapters on instruments, principles of dynamo-electrical machinery, types of d.c. generators and motors, rheostats, distributing systems, etc. The latter part of the book is devoted to a treatment of alternating current principles and machinery.

This book should be of great value to the man who wishes to obtain a clear insight into the workings of electrical machinery, but who has not the opportunity to attend school.

Trade News

THE GENERAL ELECTRIC CO. has standardized a complete line of 60-cycle synchronous condensers, for power-factor control, to meet the demand for a comparatively inexpensive, high-speed machine. These condensers are described in Bulletin No. 41,311A, superseding Bulletin No. 41,311, entitled "Synchronous Condensers."

These machines are of light mechanical construction and possess other features which permit a reduction in the amount of material required and a consequent lower cost, without lessening their value as synchronous condensers. The standard machines are designed for operation on 480, 600 and 2300 v. in the smaller sizes; 2300 v. in the intermediate sizes, and 6600 and 13,200 v. in the larger sizes.

Several advantages of making the synchronous condenser an integral part of a power system, for power-factor control, are cited by the bulletin. These involve the total cost of the equipment required to handle a given load, the regulation of long high-voltage transmission lines, additional load which can be carried, and the increased operating efficiency which is possible. The bulletin also describes the use of automatic starting and control equipment for synchronous condensers in cases where it is not always possible to have attendants; and the use of these machines to drive a mechanical load.

Calculations necessary in figuring on a synchronous condenser installation, a wiring diagram, and other data are included in the bulletin, which is illustrated with several pictures of actual installations.

GREENE, TWEED & Co. has recently issued a circular entitled Packing Economy in which is described a new plaited, graphite-treated packing designed for hydraulic and steam pressures below 100 lb. where temperature is not excessive.

NASH ENGINEERING Co., of South Norwalk, Conn., has recently issued Bulletin No. 15 illustrating and describing the Jennings Hytor vacuum heating pump.

ALLIS-CHALMERS MANUFACTURING Co.'s new bulletin No. 1117 covering "Small Generating Sets," which are particularly suitable for isolated lighting and power plants, exciter units in power plants, shipboard service, construction work, etc., has just been received.

"PENFLEX" metal hose for conveying steam, also "Penflex" clincher couplings, are described, together with illustrations and price lists, in Bulletin 52 of Pennsylvania Flexible Metallic Tubing Co., Chicago.

BULLETIN L. F. 103, on Hagan burners for power plant operation, describes the Hagan mechanical system and Hagan steam atomizing system of burning liquid fuel for the generation of steam.

FROM DAYTON-DOWD Co., Quincy, Ill., we have received a new bulletin, No. 244, on the company's type C. S. single-stage centrifugal pumps.

BULLETINS A, B and C, illustrating and describing the Monarch soot blower for different types of boilers, was lately received from Monarch Soot Remover Co., Inc., Quincy, Mass.

ATLAS VALVE Co.'s Bulletin No. 5, Edition No. 1, describes and illustrates the Victor damper regulator, No. 3, high pressure, which is designed for boiler pressures up to 250 lb.

DESCRIPTION, illustrations and price lists of oil burners, oil burning systems, oil strainers, pump governors, relief valves and other apparatus made by Staples & Pfeiffer, of San Francisco, are contained in that company's Catalog No. 21.

SPACE HEATERS for commercial and domestic heating are illustrated and discussed in a leaflet just issued by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. The construction and distinctive features, as well as the application of these heaters, are given, together with over 100 specific uses.

THE HAGAN CORP. has recently issued a bulletin on the Hagan De-Concentrator, an apparatus whose function it is to reduce continually the concentration of scale-forming elements in boiler water. The de-concentrator handles the hot water as it is circulated in the boiler and takes out the precipitate as it is formed.

THE FILES Engineering Company, Inc., of Providence, R. I., has recently published a pamphlet on its hand-operated stoker. This book comprises a short treatise on stoker operation and combustion control besides a description of the Files stoker and its operation. A section is devoted to the various fuels that may be burned on this grate, saving in labor effected, smokelessness of combustion, efficiencies obtainable and to the overload capacities which can be handled. The Files mechanical feed is also briefly discussed.

THE WAYNE Oil Tank & Pump Co., in its recent bulletins Nos. 25 and 5000 on oil storage and oil filtration, describe, in the first, various types of oil storage installations to meet the different requirements of various industries, and, in the second, recommended oil filtration systems.

This second bulletin treats also in more or less detail the question of lubricating methods as they effect a saving in fuel, of bearing renewals, shutdowns, labor and depreciation. Comparative tests of new and filtered oil as regards the coefficient of friction, bearing temperatures, viscosity, and chill, flash, and fire points are cited. Oil clarification by precipitation and filtration are compared.

Steam turbine oil filtration methods for both vertical and horizontal turbines are described. And the relative merits of continuous, partial and batch filtration are discussed.

NATIONAL LAMP WORKS, of the General Electric Co., has recently issued Bulletin No. 41, entitled "Illumination Design Data," by Earl A. Anderson.

The bulletin presents a simple method of illumination design adapted to general lighting systems where standard equipment is to be used. The methods of design presented in this bulletin will be found fully as simple as any of the common short cuts. It has the decided advantage that the technical considerations which are important as influencing the result and which require the experienced judgment of the engineer have been taken into account in the preparation of the charts and tables contained in the bulletin and therefore automatically receive due allowance in the lighting design. The data apply in interiors where standard types of reflecting equipment are used to obtain general lighting of substantially uniform intensity.

The bulletin is well illustrated with numerous charts and diagrams, and includes a particularly interesting chart in colors, showing the various reflection factors of colored surfaces. Definitions of terms employed in the illuminating engineer's art are given and the subject of design has been handled in an unusually interesting and effective manner.

THE WHEELER CONDENSER & ENGINEERING Co., Carteret, N. J., announces the publication of the 1921 edition of its "Steam Tables for Condenser Work." This is the sixth edition of a work which for many years has been widely used by engineers dealing with the condensation or evaporation of steam. The tables are in a book form, pocket size. The properties of saturated steam are tabulated from 29.8 in. vacuum to atmospheric pressure in increments of tenths of an inch referred to a 30-in. barometer.